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Duley et al.

(10) **Patent No.: US 6,977,355 B2**
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(54) **TAILORED BLANK**

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(21) Appl. No.: **10/171,538**

(22) Filed: **Jun. 17, 2002**

(65) **Prior Publication Data**

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Related U.S. Application Data

(63) Continuation-in-part of application No. 09/694,889, filed on Oct. 25, 2000, now abandoned, and a continuation-in-part of application No. 09/341,575, filed as application No. PCT/CA97/00854 on Nov. 13, 1997, now Pat. No. 6,426,153.

(30) **Foreign Application Priority Data**

Jan. 14, 1997 (GB) 9700652

(51) **Int. Cl.**[7] **B23K 26/00**; B23K 33/00

(52) **U.S. Cl.** **219/121.64**; 228/173.6; 428/577; 428/579; 428/582; 428/614

(58) **Field of Search** 428/577, 578, 428/579, 582, 596, 614; 219/121.63, 121.34; 228/173.2, 173.6, 173.3

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Primary Examiner—John J. Zimmerman
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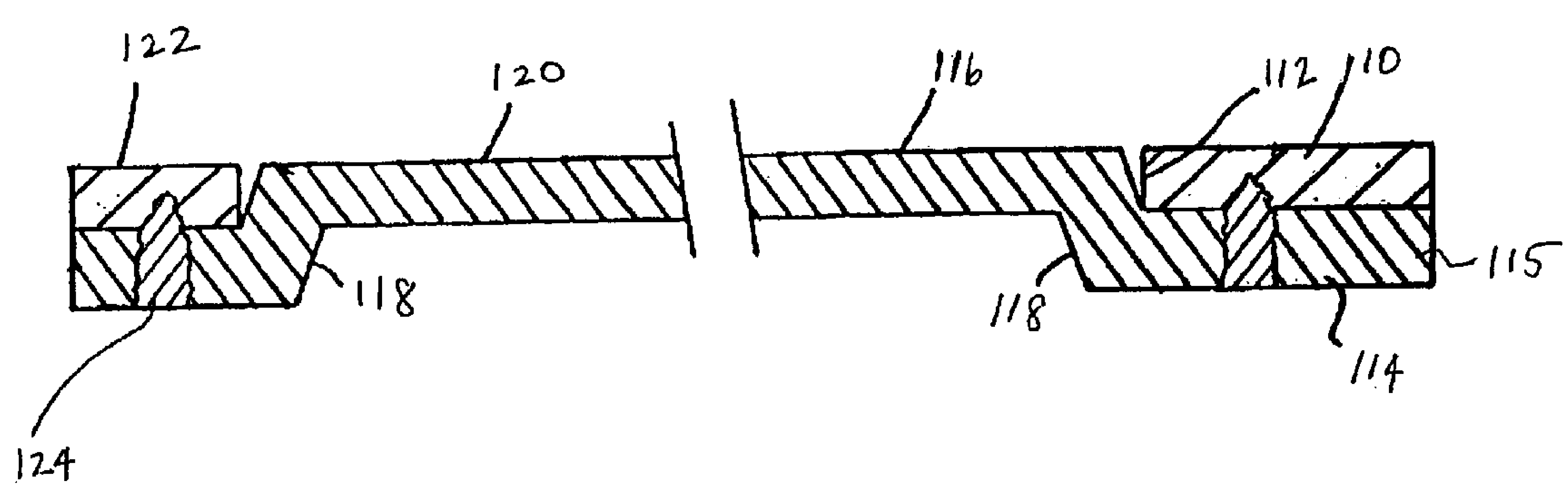
(57) **ABSTRACT**

The present invention provides a tailored blank having a pair of sheet metal constituent parts each having a pair of oppositely directed major surfaces. The first constituent part has an aperture while the second constituent part has an embossment to fit the aperture. The first and second constituent parts are then secured to one another to form the tailored blank. The blank may then be subsequently formed into a component of varying material characteristics.

1 Claim, 13 Drawing Sheets



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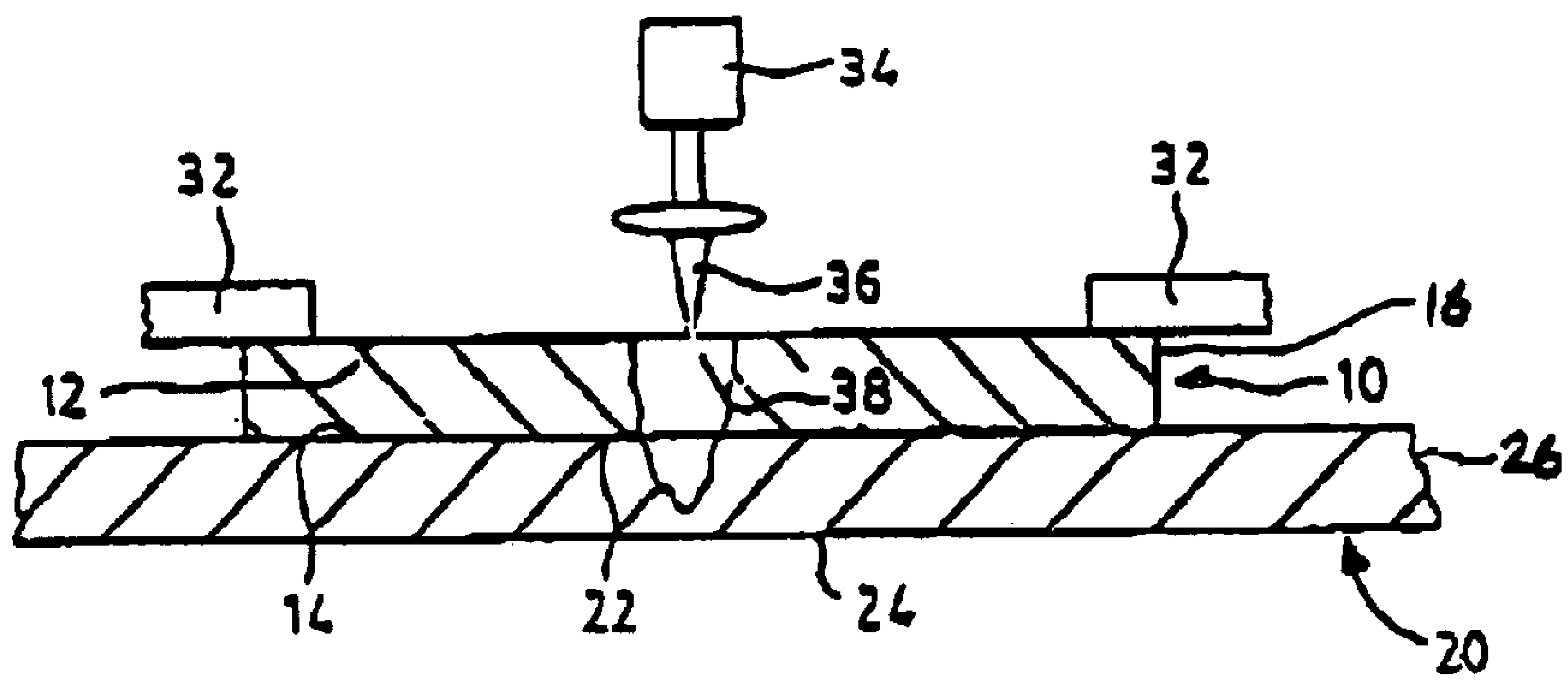


FIG. 1

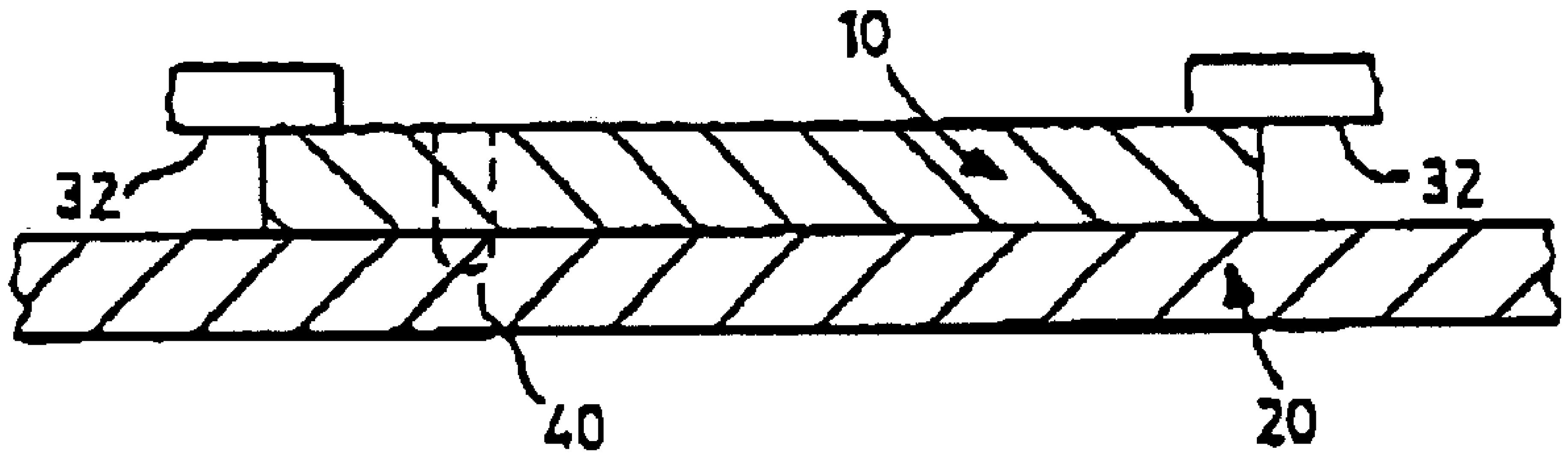


FIG. 2

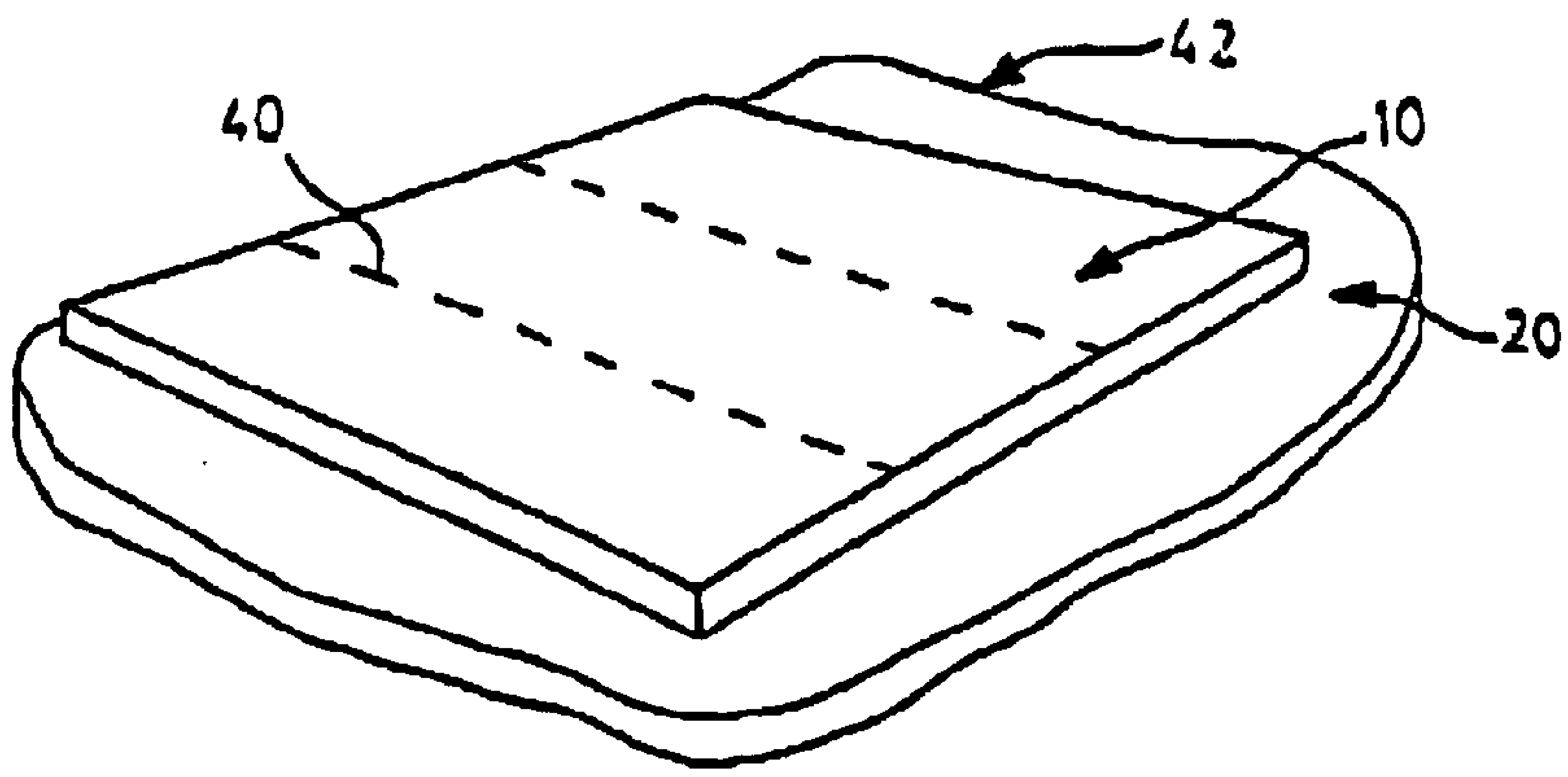


FIG. 3

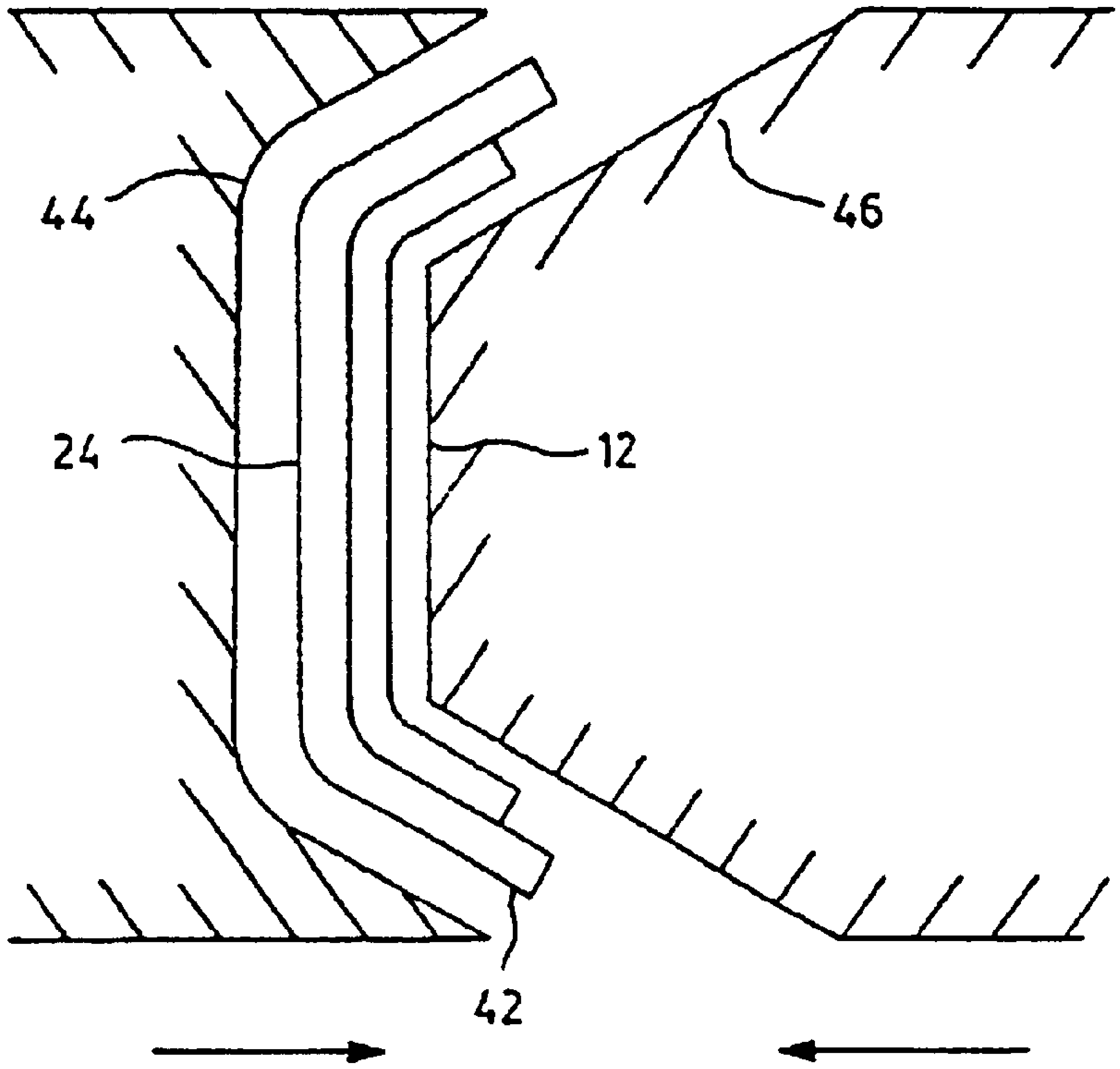


FIG. 4

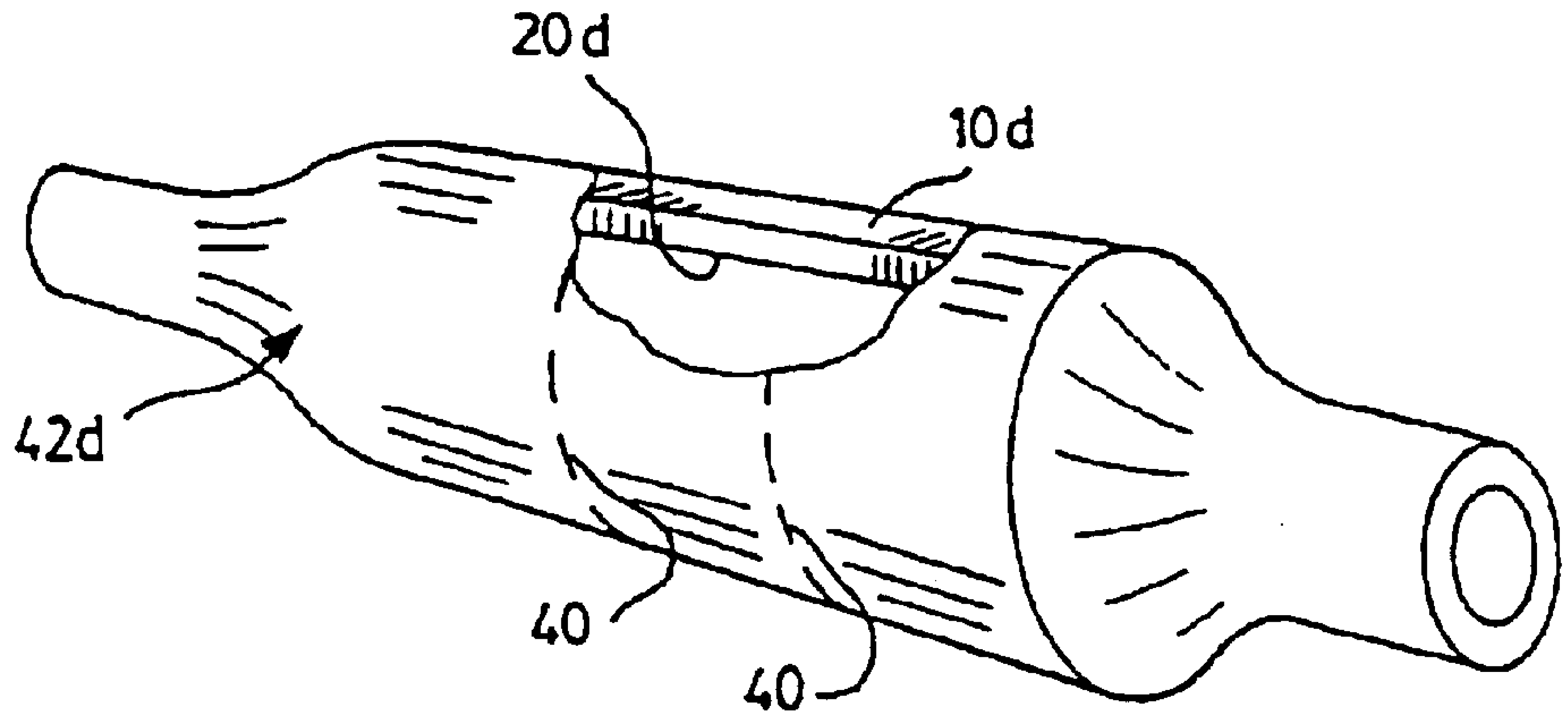


FIG. 9

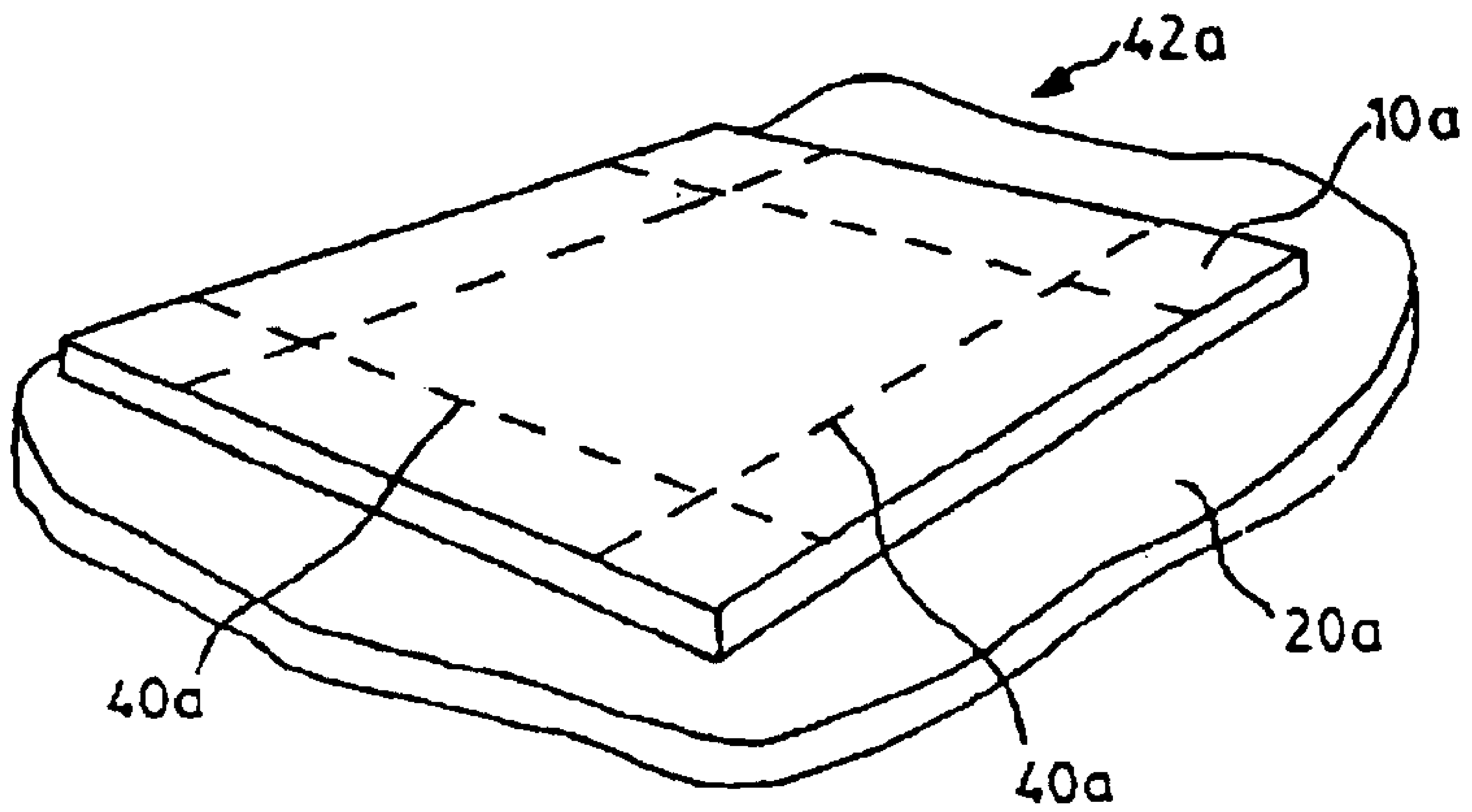


FIG. 5

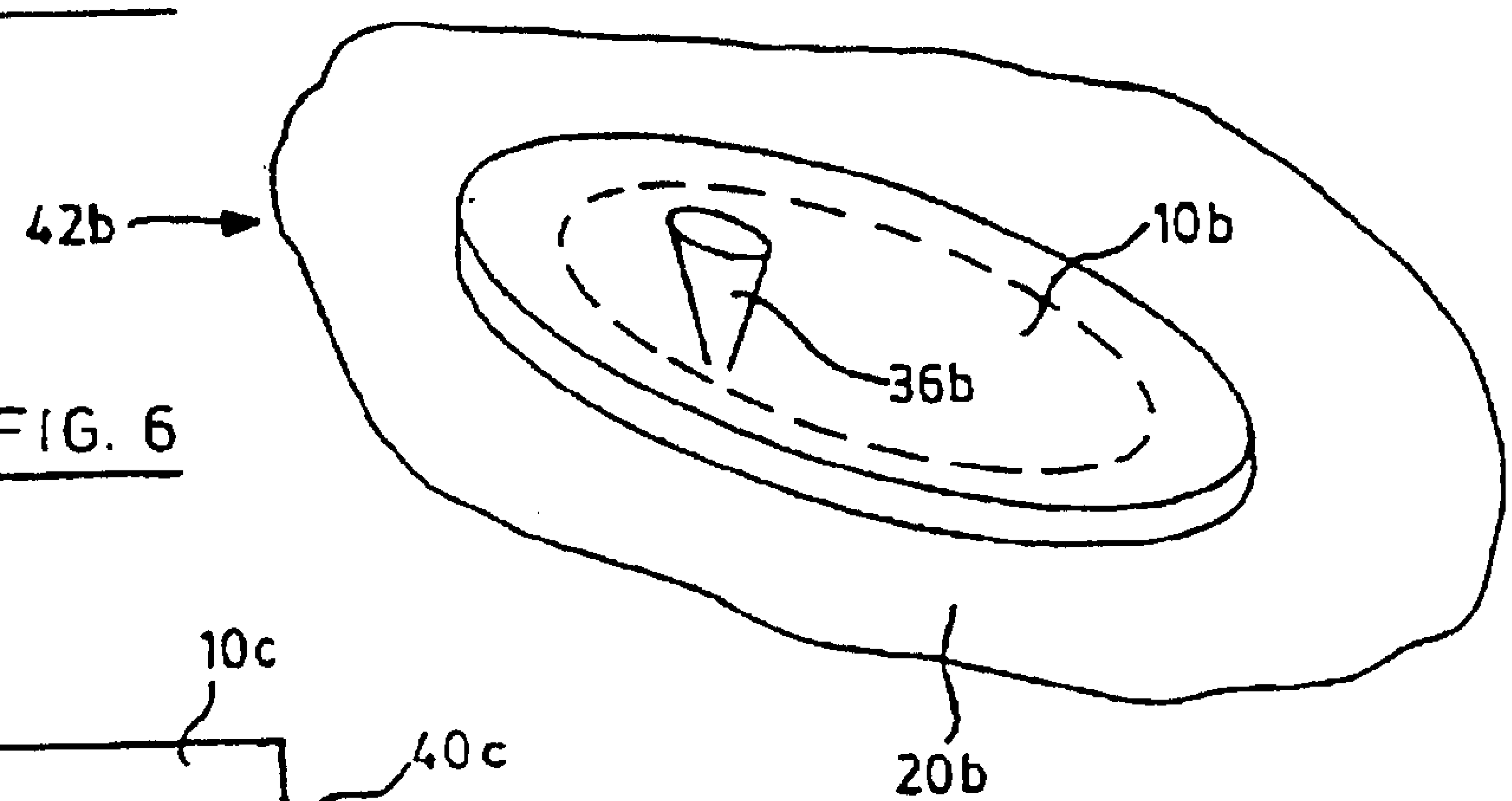


FIG. 6

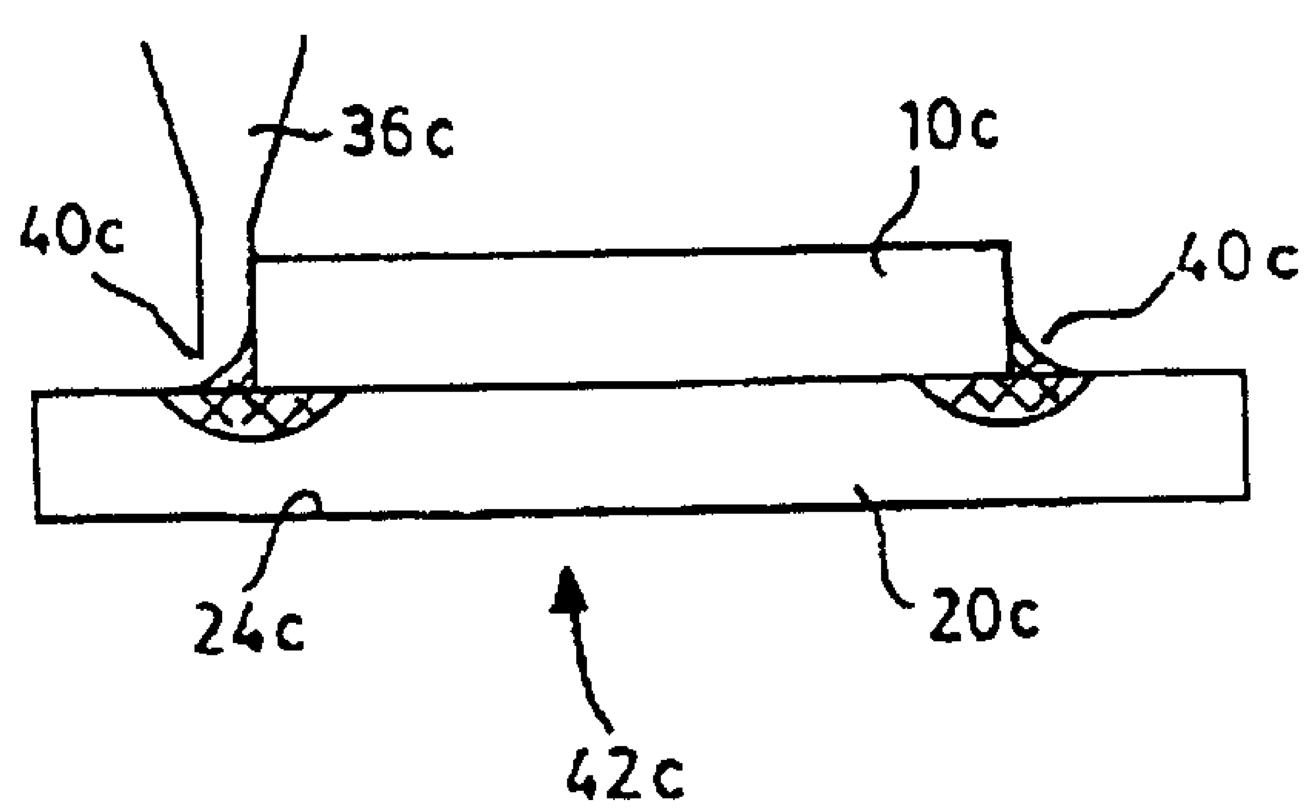


FIG. 7

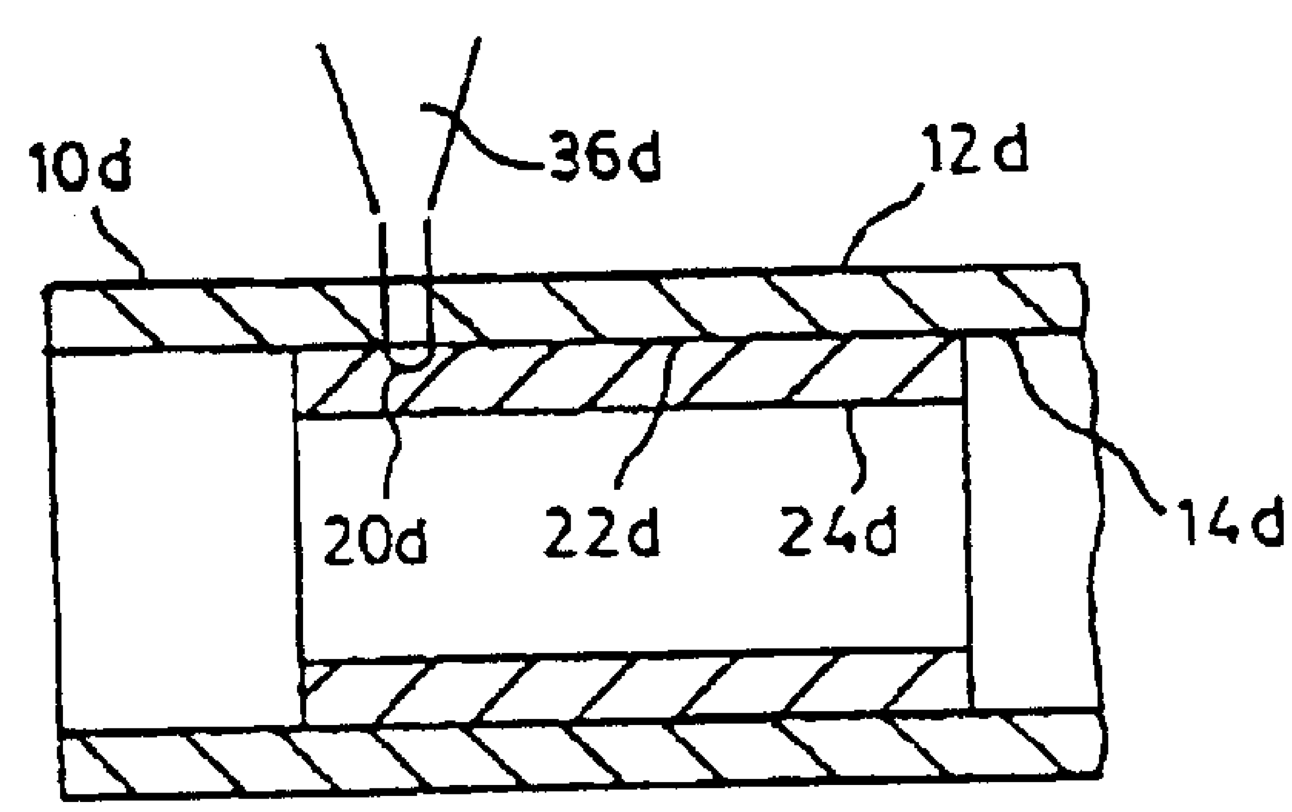


FIG. 8

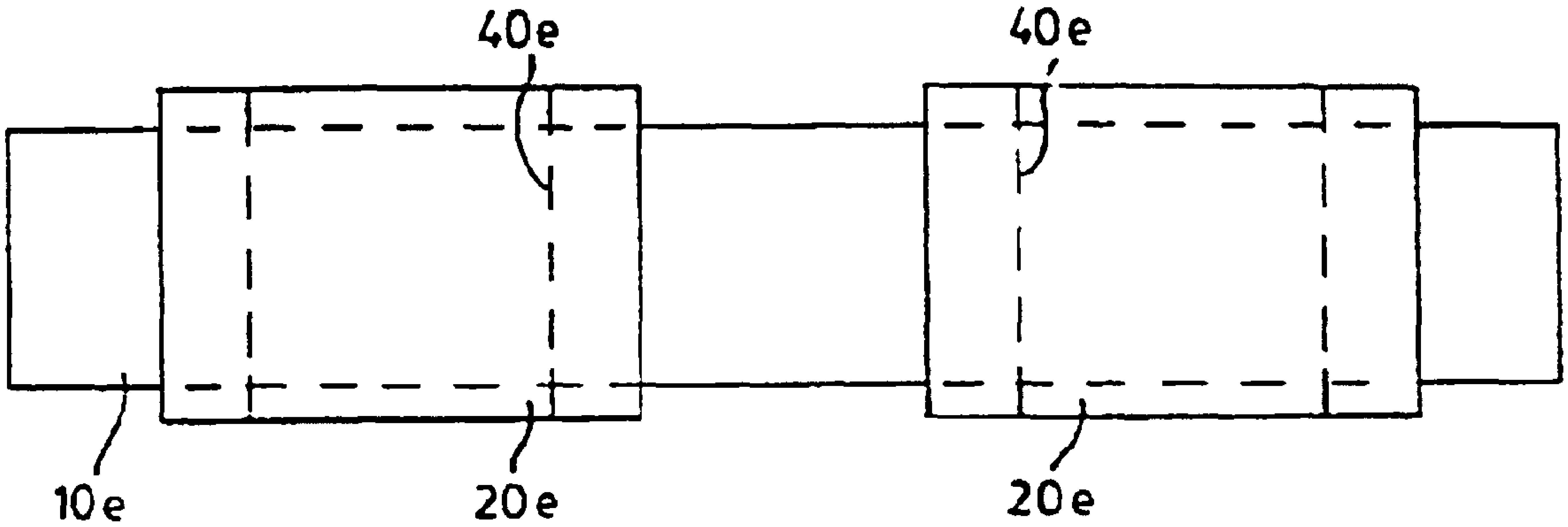


FIG. 10

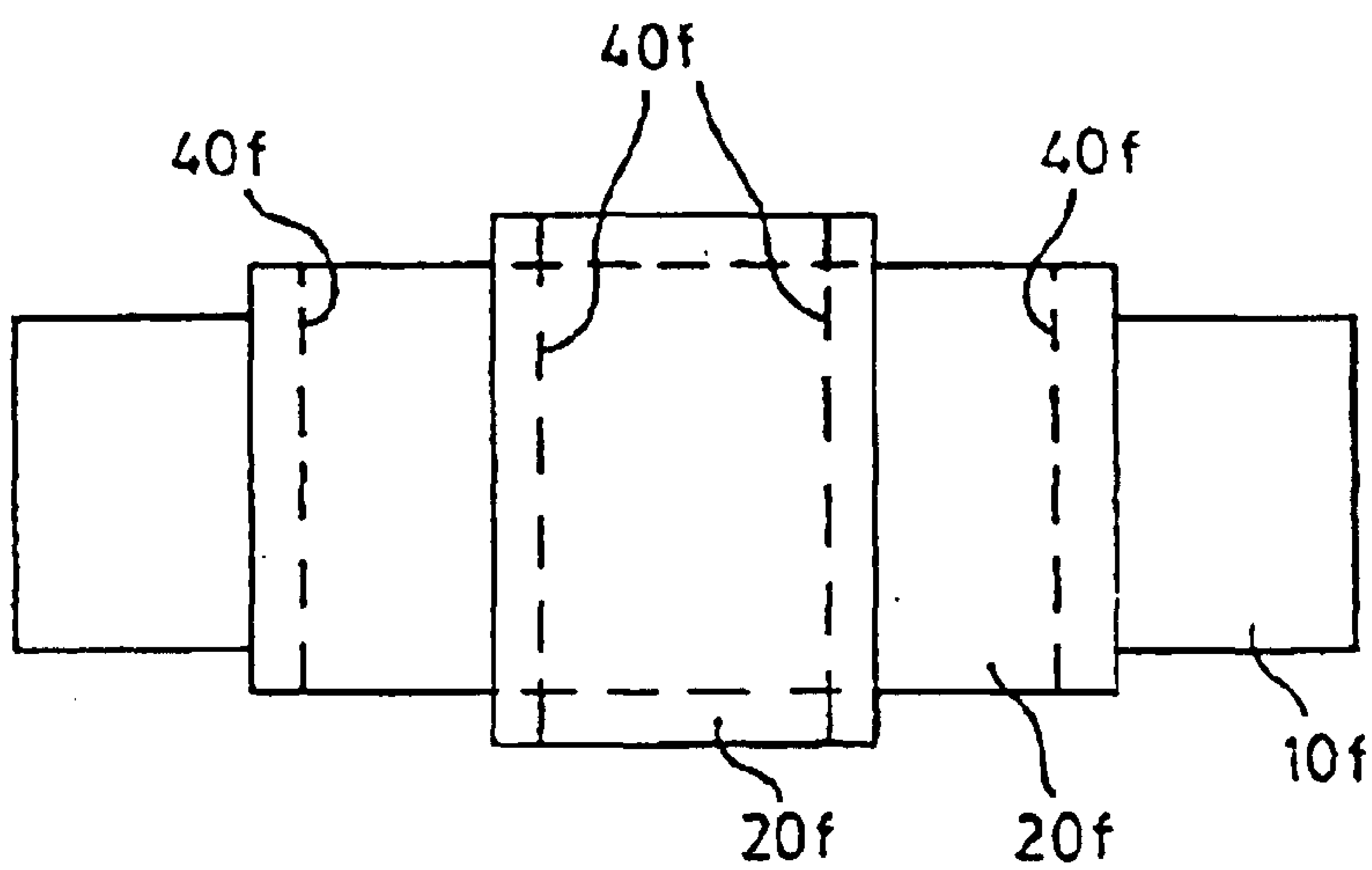


FIG. 11

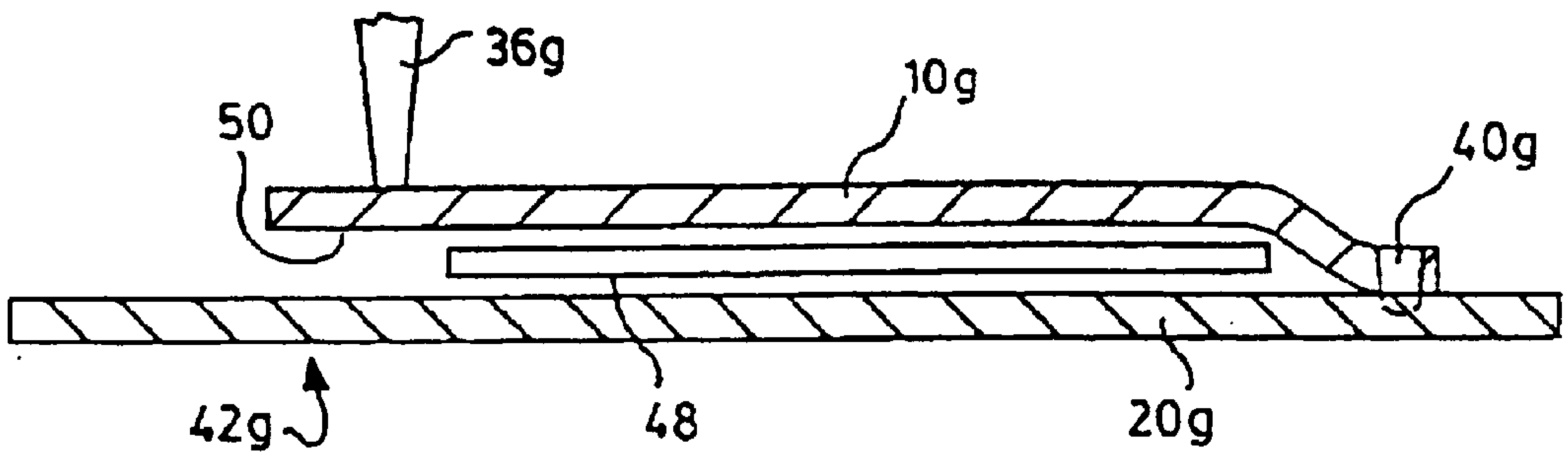


FIG. 12

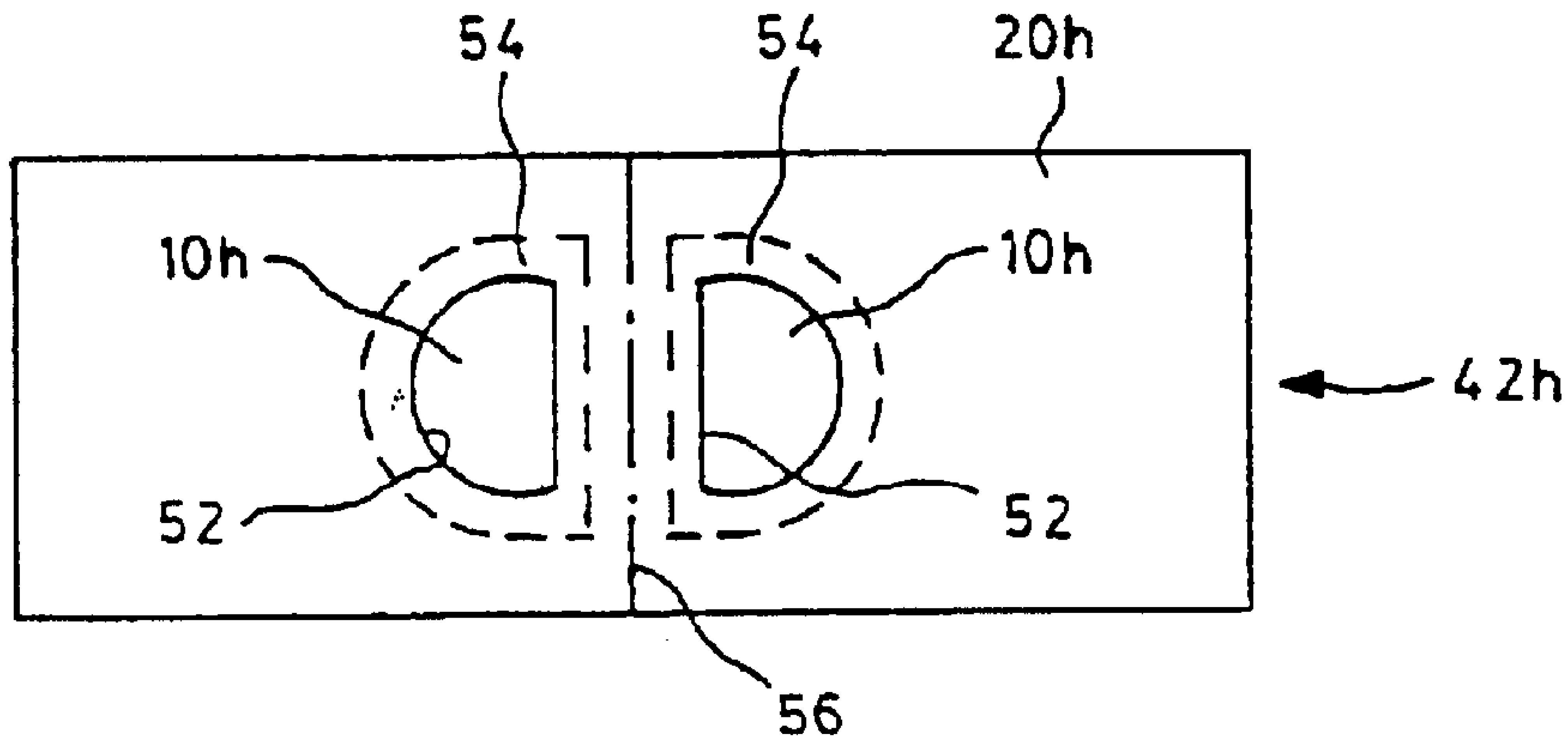


FIG. 13

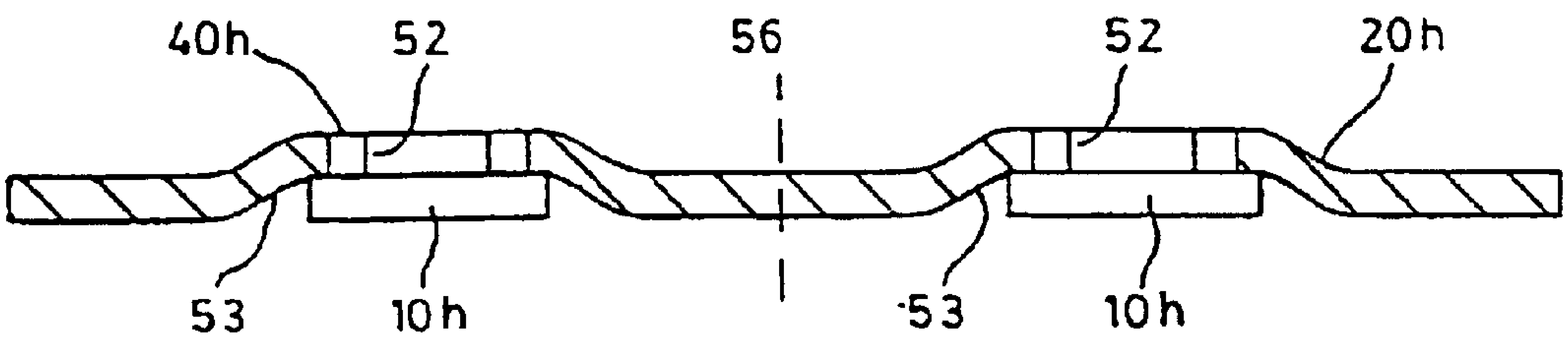


FIG. 14

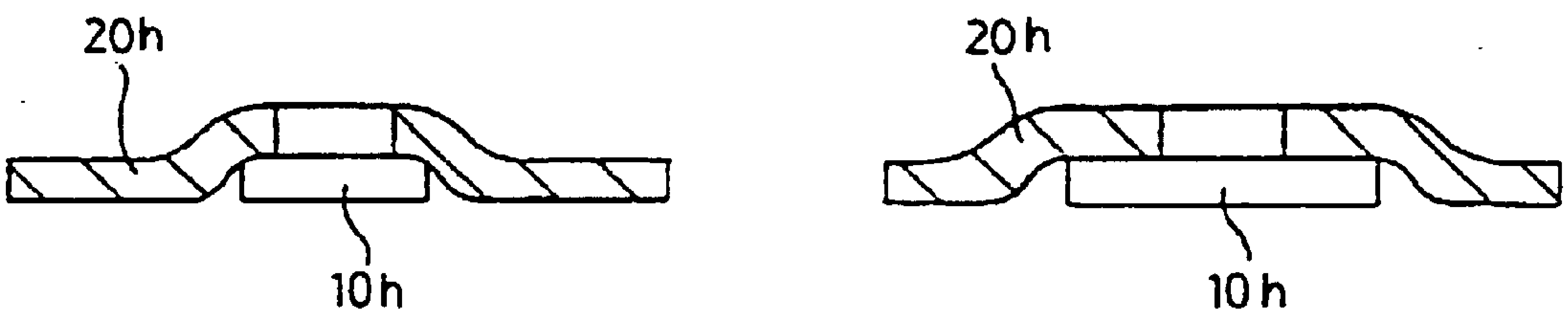


FIG. 15

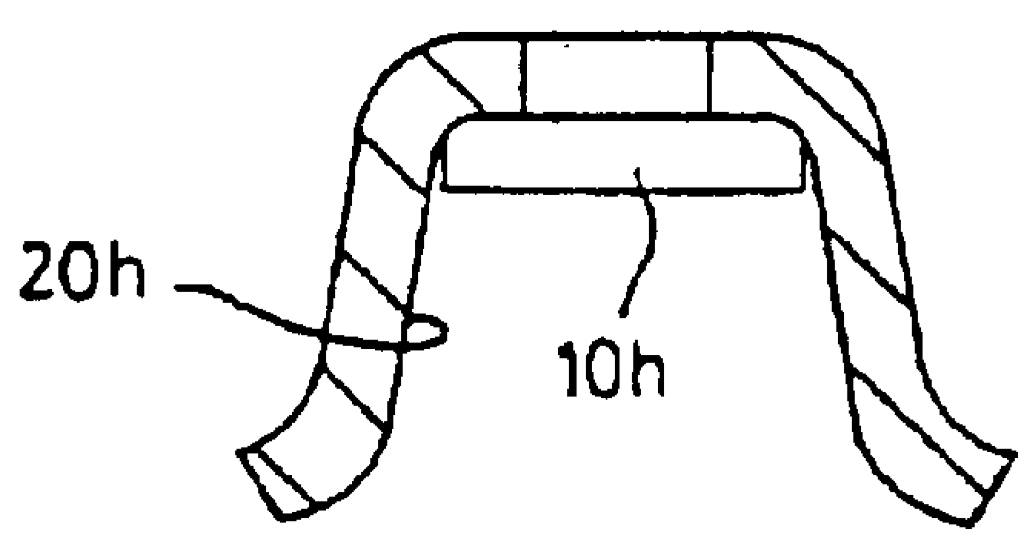


FIG. 16

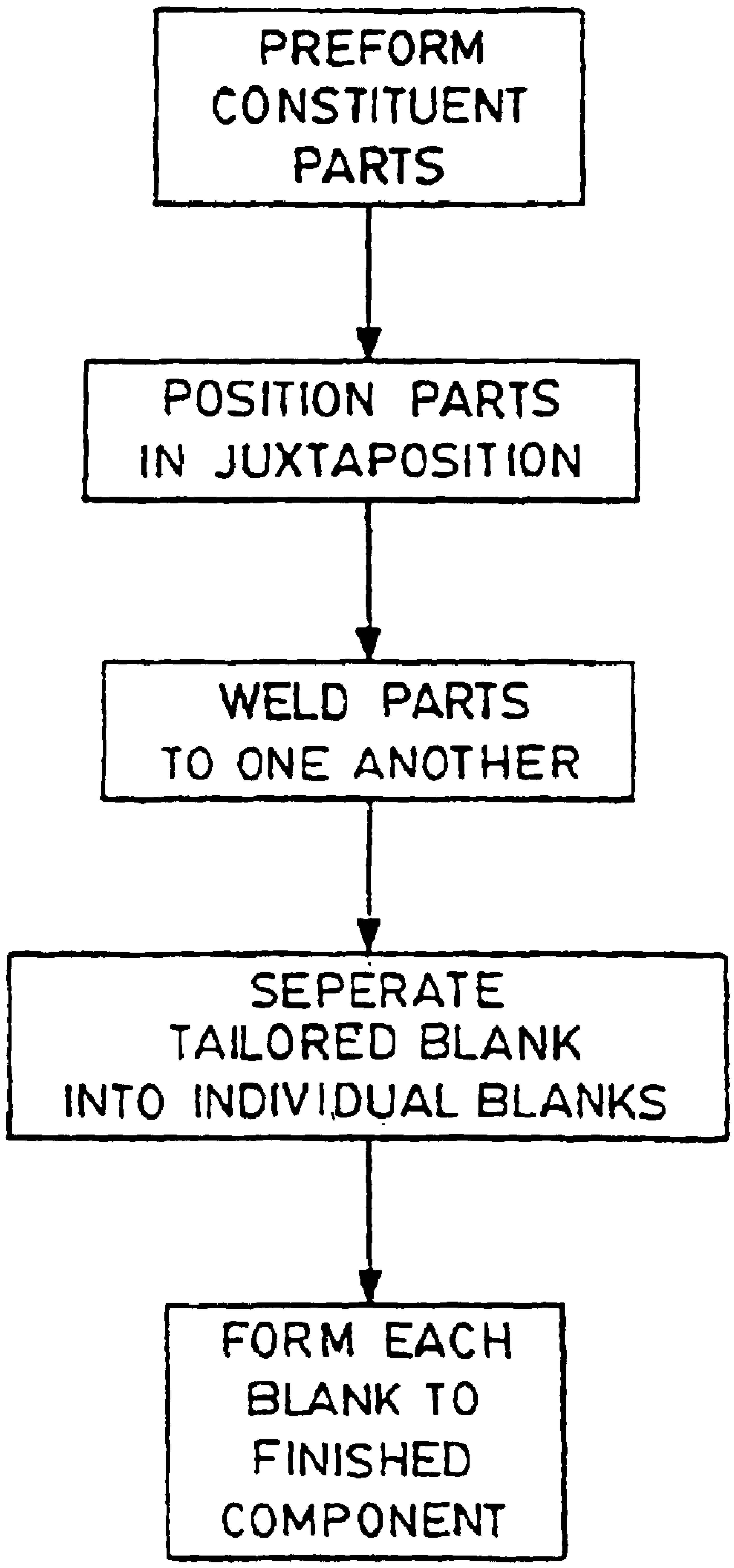

PREFORM CONSTITUENT PARTS
POSITION PARTS IN JUXTAPOSITION
WELD PARTS TO ONE ANOTHER
SEPERATE TAILORED BLANK INTO INDIVIDUAL BLANKS
FORM EACH BLANK TO FINISHED COMPONENT

FIG. 17

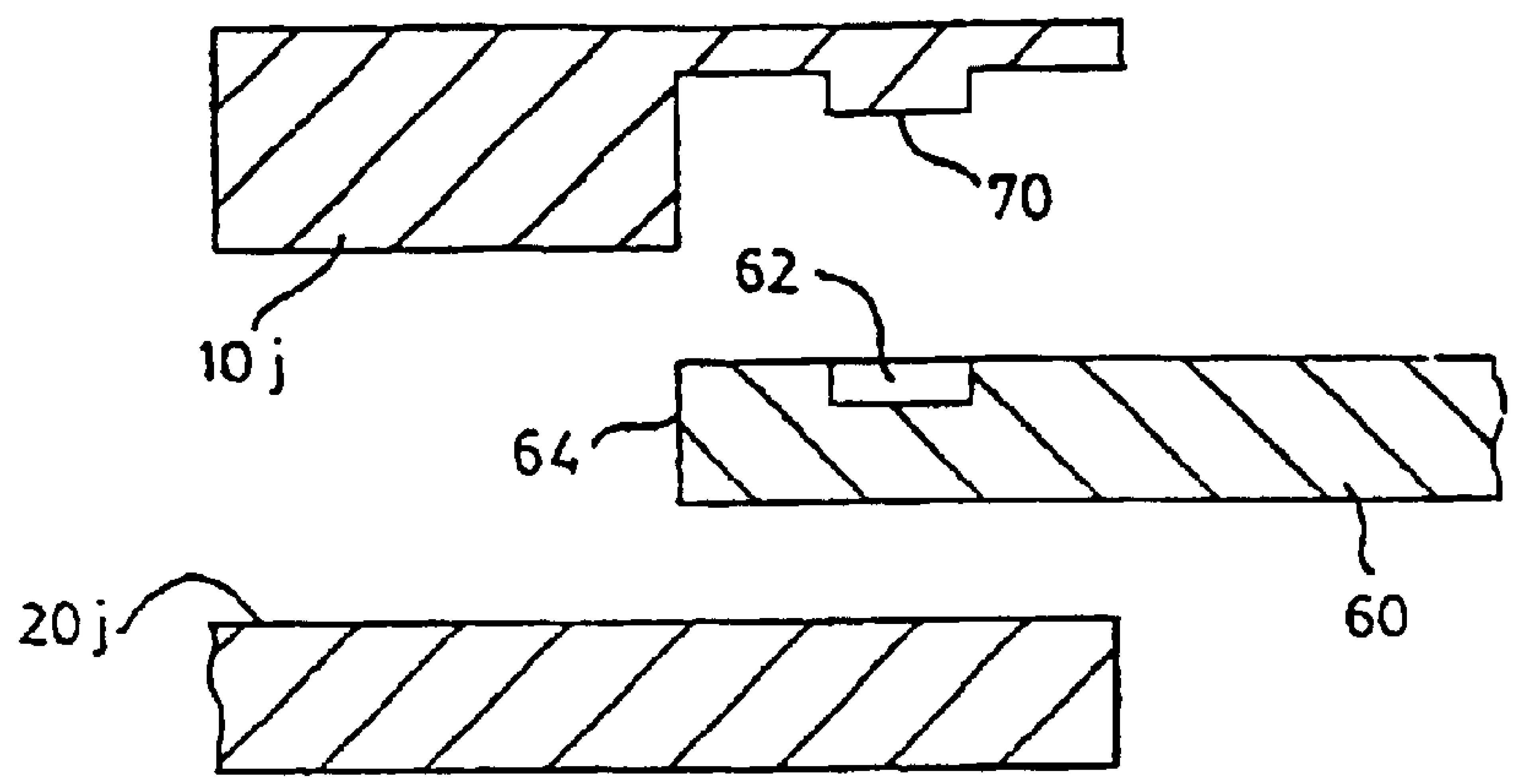


FIG. 18

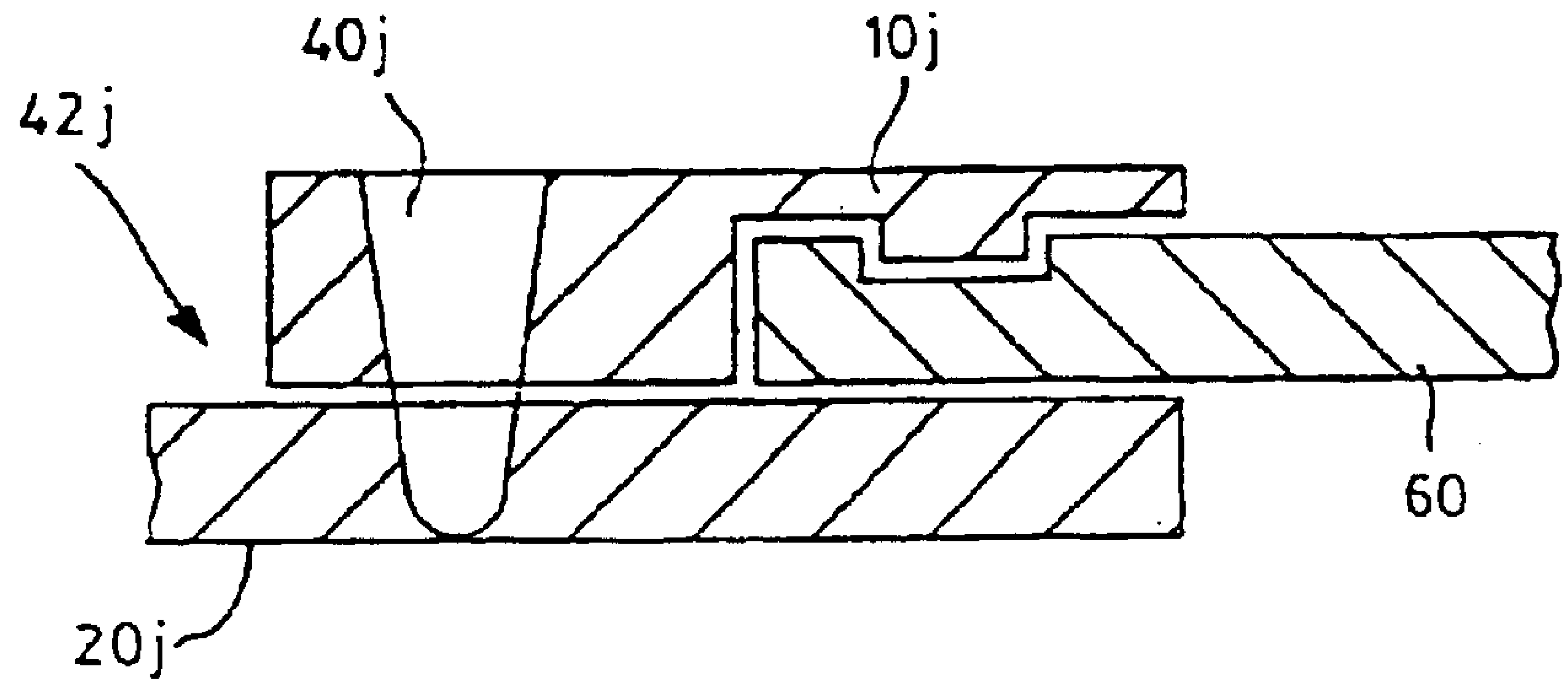


FIG. 19

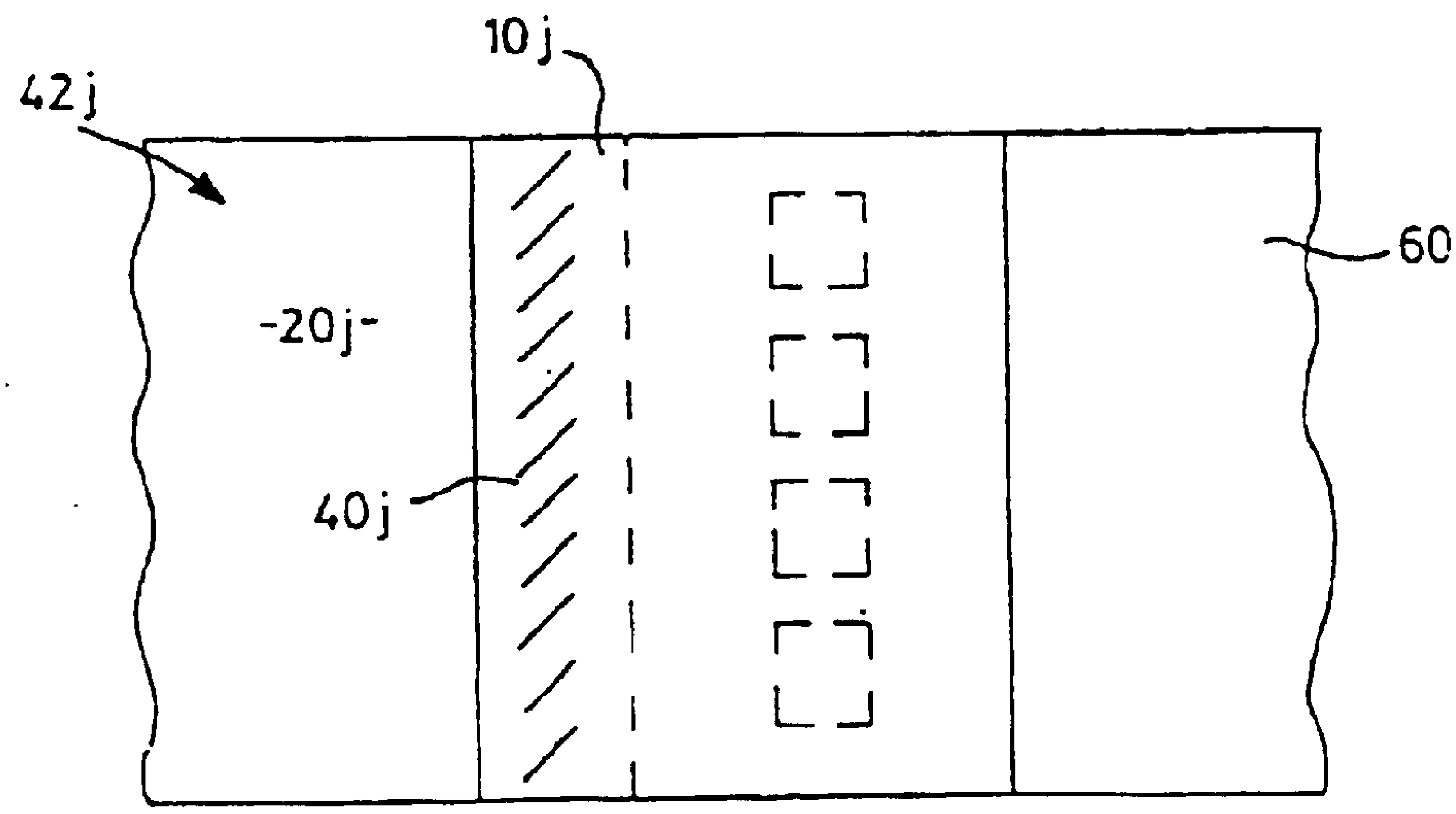


FIG. 20

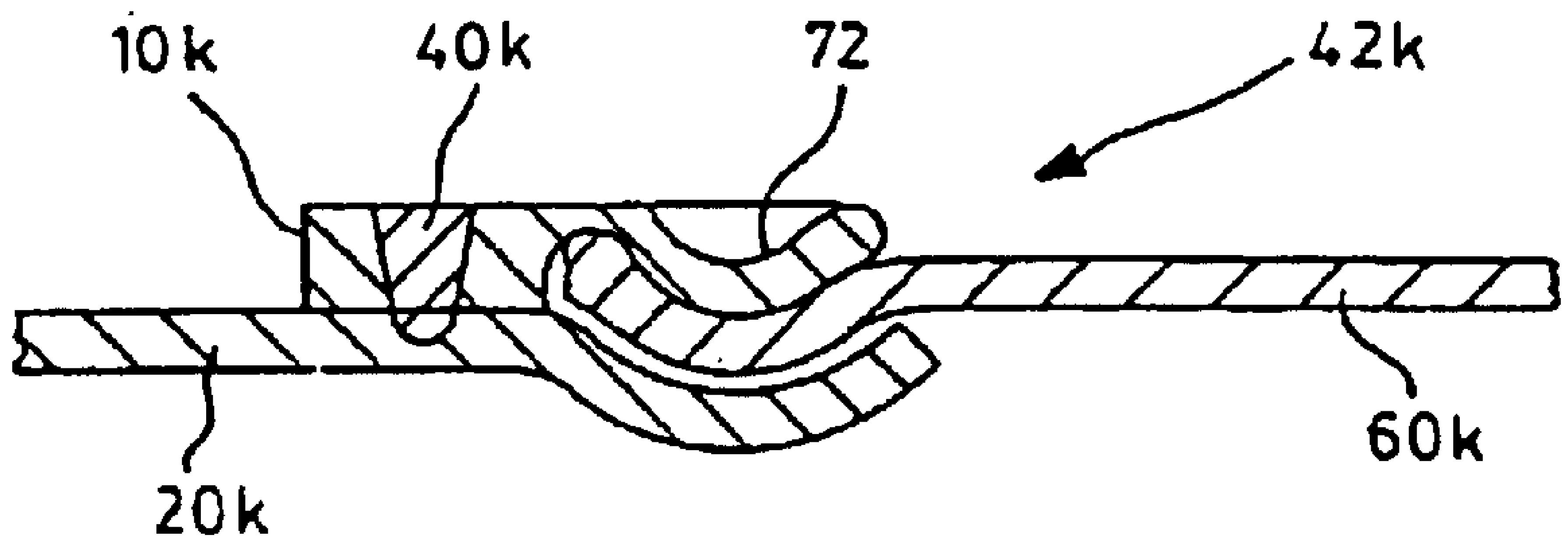


FIG. 21

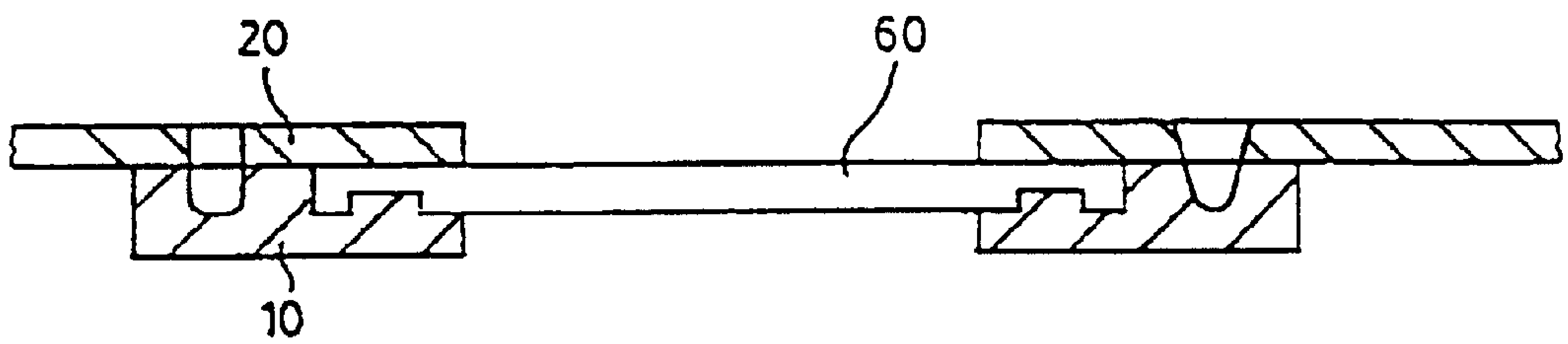


FIG. 22a

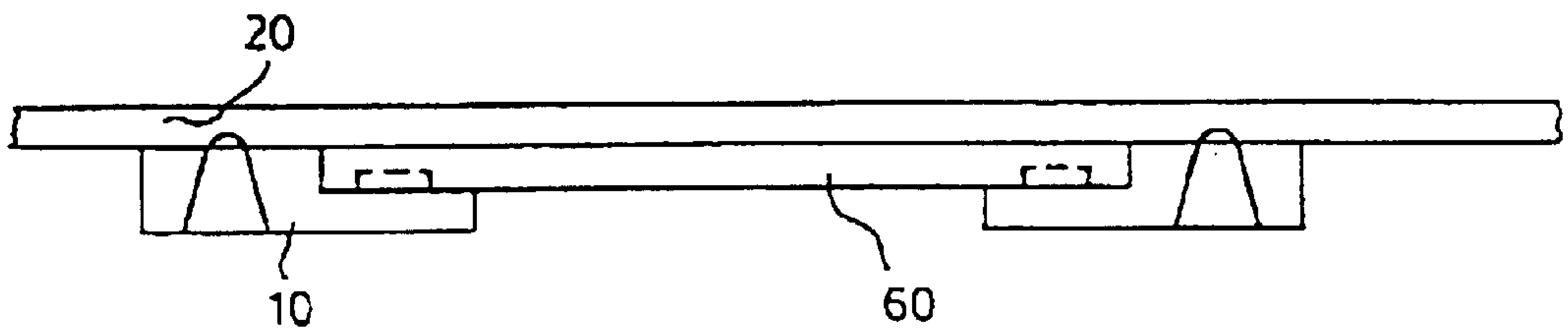


FIG. 22b

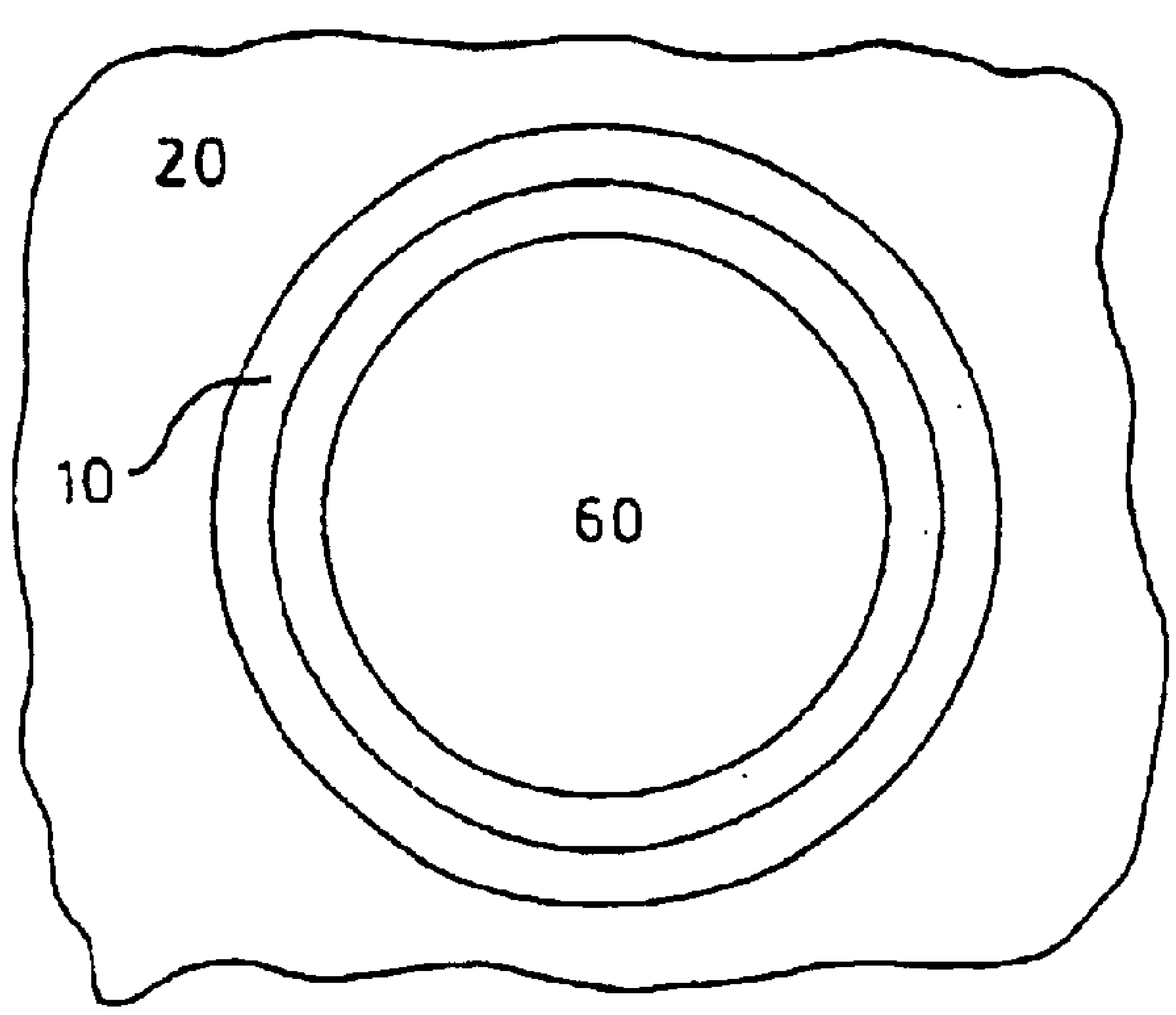


FIG. 22c

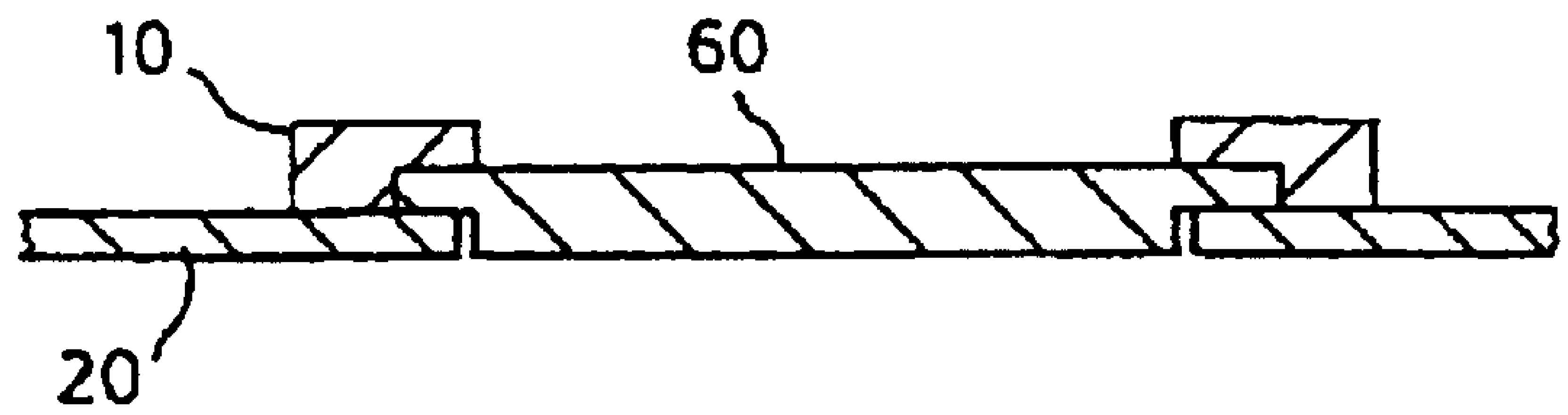


FIG. 22d

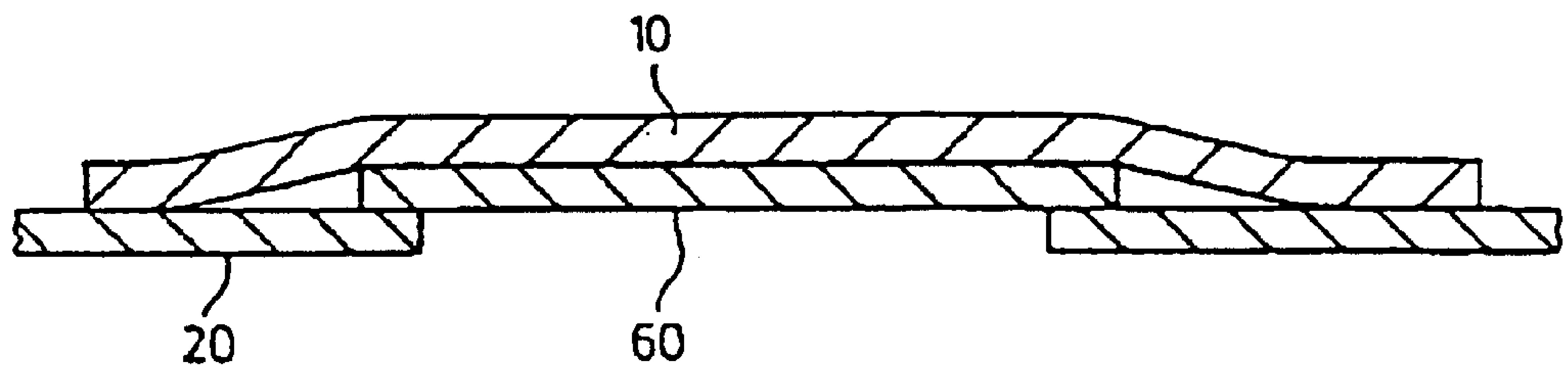


FIG. 22e

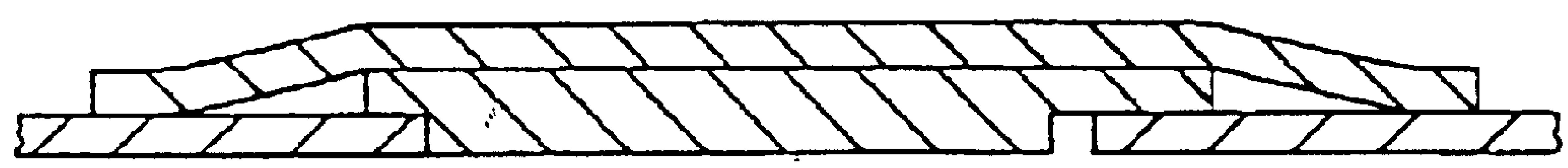


FIG. 22f

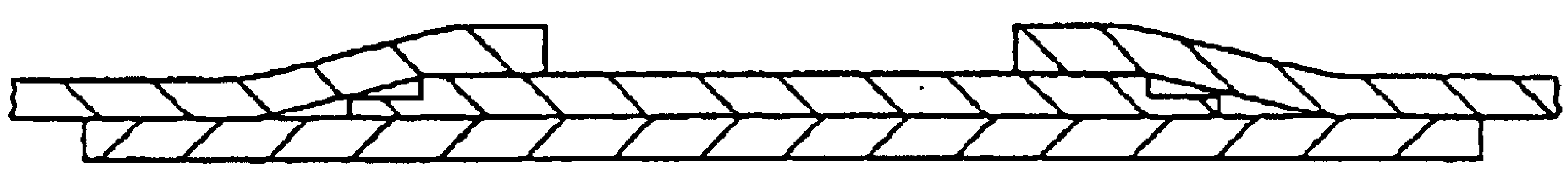


FIG. 22g

FIG. 22h

FIG. 23

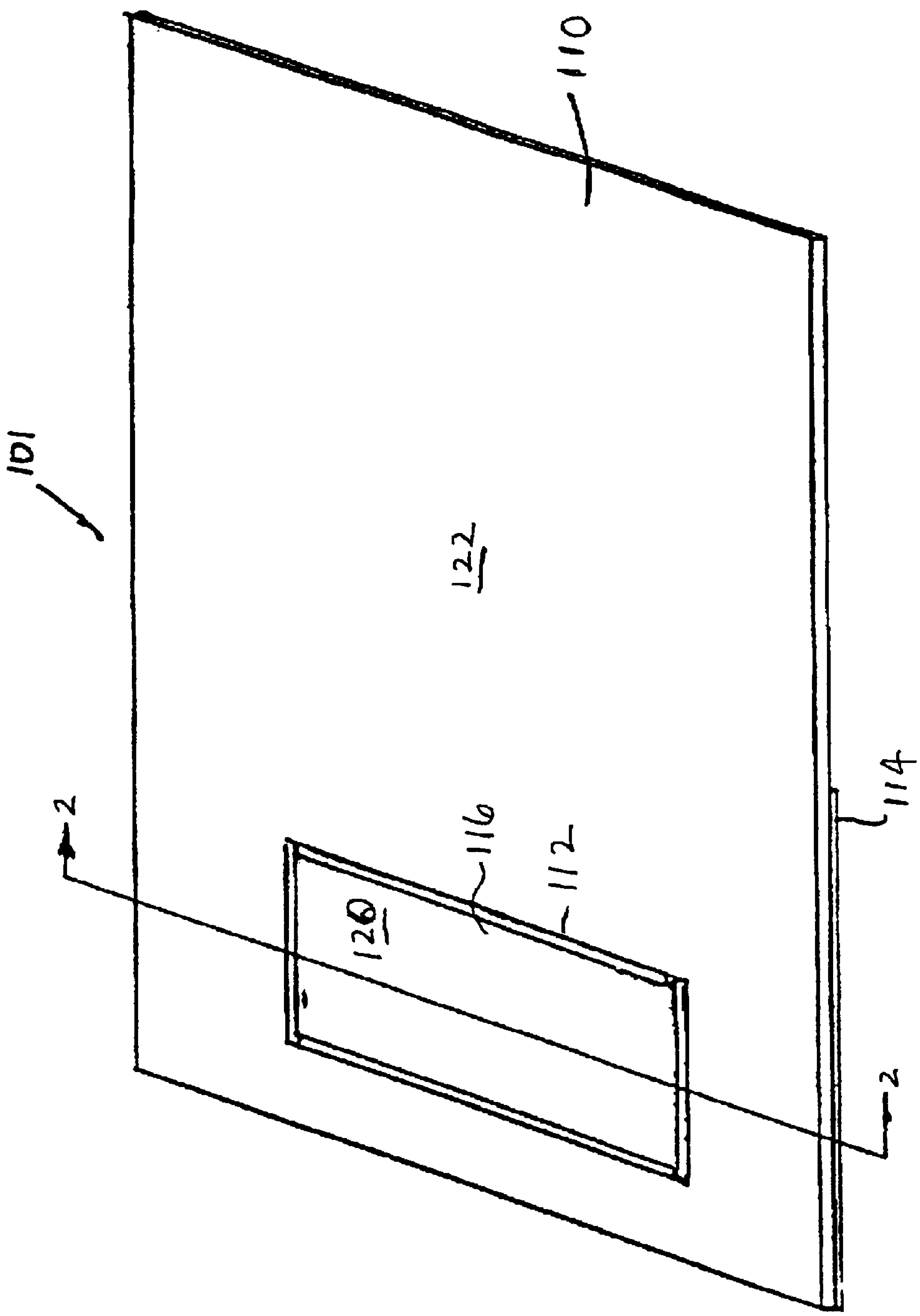


FIG. 24

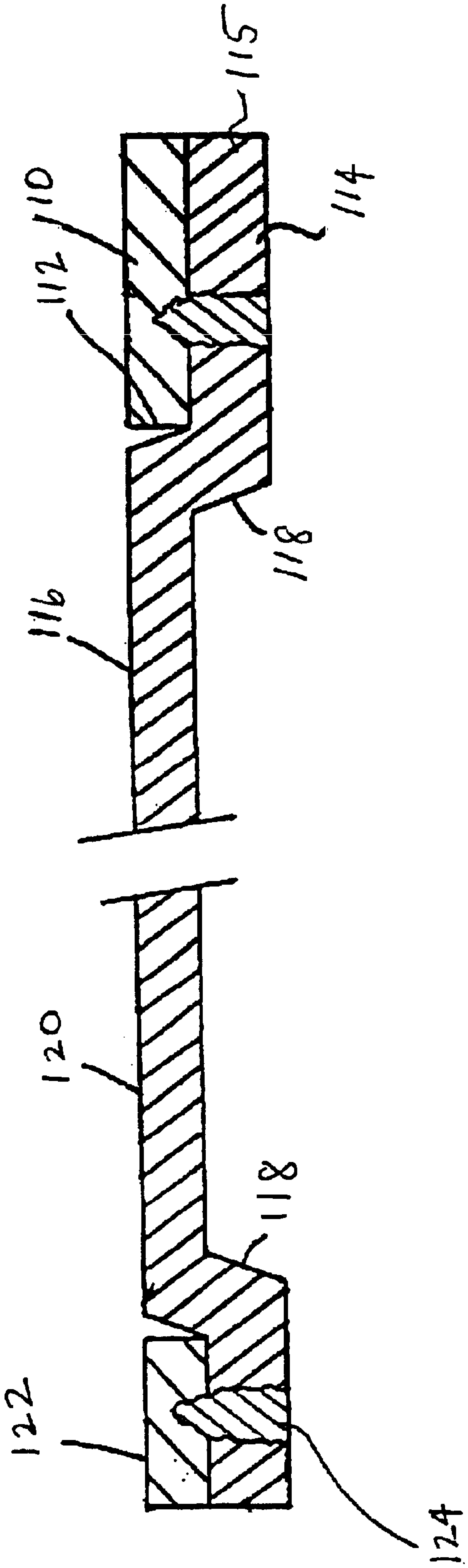
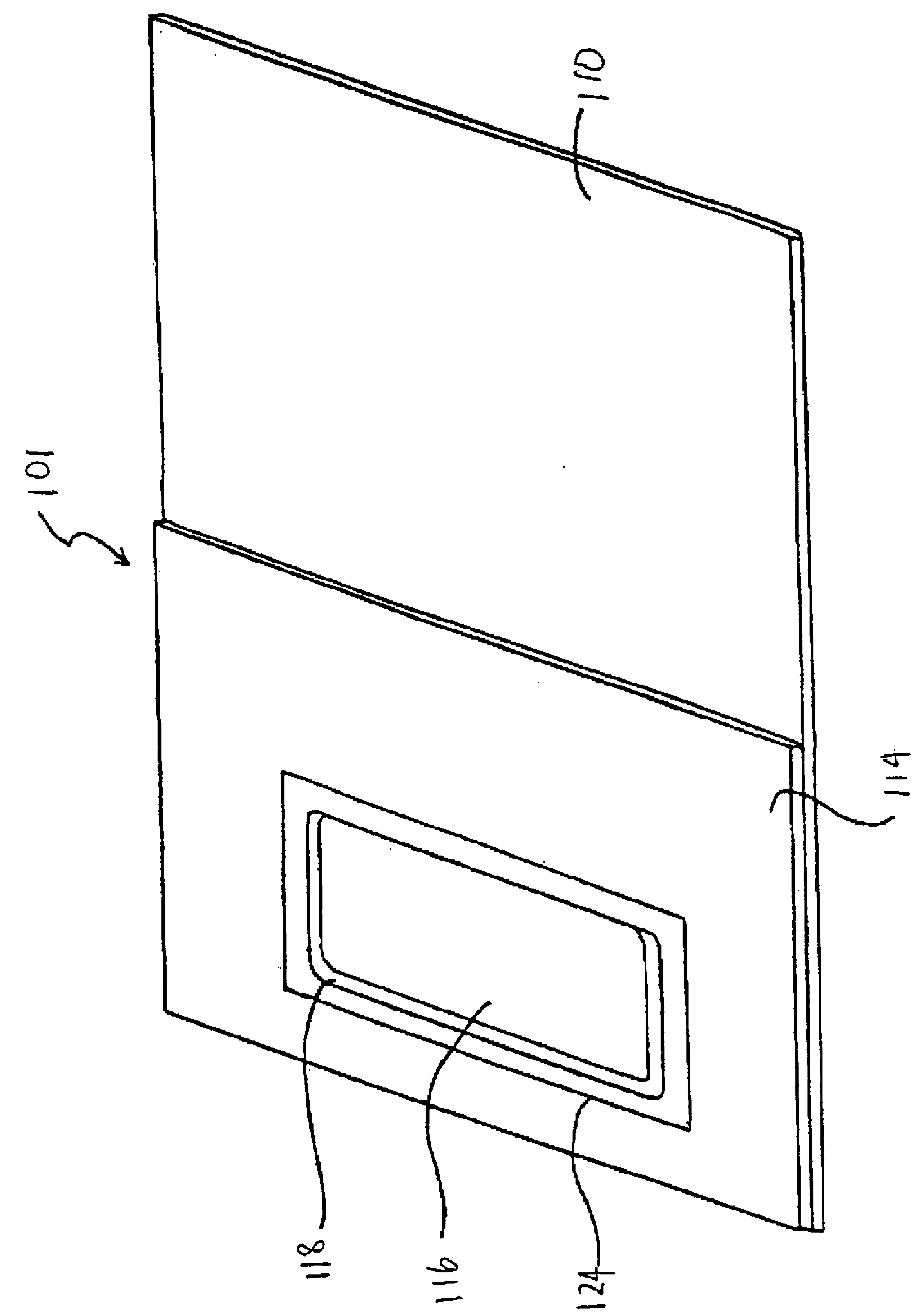


FIG. 25



TAILORED BLANK

This application is a Continuation-In-Part of U.S. Ser. No. 09/694,889 filed on Oct. 25, 2000 now abandoned and U.S. Ser. No. 09/341,575 filed on Oct. 1, 1999, now U.S. Pat. No. 6,426,153 which is a 371 of PCT/CA97/00854 filed on Nov. 13, 1997 the contents of which are incorporated herein by reference.

FIELD OF THE INVENTION

The present invention relates to a method of forming tailored blanks to be used to produce shaped metal components.

BACKGROUND OF THE PRIOR ART

Sheet metal components of complex shapes are typically produced from a planar blank that is formed into the finished shape through a series of forming or stamping operations. Where relatively complex components are to be produced, it is usual to build the component out of a number of individual elements, each of which is stamped from a blank. The need to use multiple components may result from the complexity of the finished product or may result from the different characteristics of the material required in different areas of the component. For example, if the component is a door frame of an automobile, the majority of the door frame may be formed from a relatively thin metal sheet but the mounting points for the hinges of the door require extra strength. The use of multiple elements to produce the finished component increases the manufacturing complexity.

To mitigate this complexity, it has been proposed to produce a tailored blank in which appropriately shaped sheets of material are connected edge to edge by a laser welding process to produce a unitary blank. When formed, the blank produces a component with differing material characteristics through the structure. This process permits optimum use of the material but at the same time minimizes the subsequent assembly of multiple elements into the final component.

The production of a tailored blank requires the constituent sheet metal parts to be cut accurately so that the laser welding may be performed efficiently and retain an adequate weld quality. This requires precision cutting of the constituent components and in our published Application Nos. 9624039.5 filed Nov. 19, 1996, 9624652.5 filed Nov. 27, 1996 and Application No. 9700251.3 filed Jan. 8, 1997, each of which were filed in Great Britain and are abandoned, various methods are described to mitigate the difficulties encountered with obtaining the required precision from the constituent parts. However, in certain circumstances, it is desirable to produce a formed component with a very high quality surface finish so that subsequent processing such as painting can be accomplished with a minimum of refurbishment of the surface after welding. While laser welding offers in general a relatively high-quality welded surface and the processes contemplated in the above-mentioned applications further facilitate the production of a smooth outer surface, there is nevertheless the need for a tailored blank that may be used directly to produce a finished surface.

It is therefore an object of the present invention to obviate or mitigate the above disadvantages.

SUMMARY OF THE INVENTION

In general terms, the present invention provides a method of forming a component from a tailored blank having two constituent parts comprising the steps of providing a first constituent part having an aperture; providing a second constituent of substantially uniform cross section having an embossment to fit the aperture and a surrounding flange to extend beyond the periphery of the aperture and overlap the first constituent part, the embossment being offset from the flange by the thickness of the first constituent part; positioning the first and second constituent parts in face to face relation with the second constituent part nesting the embossment within the aperture; securing the first and second constituent parts to one another to form a substantially planar tailored blank by laser welding the flange to the first constituent part by continuously welding between the flange and first constituent part, wherein the step of nesting the embossment in the aperture results in a flush surface between the first constituent part and the embossment; and deforming the blank the provide the component.

BRIEF DESCRIPTION OF DRAWINGS

Embodiments of the invention will now be described by way of example only, with reference to the accompanying drawings in which

FIG. **1** is a sectional view of a pair of constituent parts prior to processing;

FIG. **2** is a sectional view of the components after processing;

FIG. **3** is a top perspective view of the components after processing;

FIG. **4** is a schematic representation of a part formed from the components of FIG. **3**;

FIG. **5** is an alternative embodiment of tailored blank;

FIG. **6** is a further embodiment of a tailored blank;

FIG. **7** is a sectional view of an alternative processing arrangement of a tailored blank;

FIG. **8** is a sectional view showing the processing of tubular components;

FIG. **9** is a perspective view of a finished component formed from the blank of FIG. **8**;

FIG. **10** is a side view of a further embodiment of blank similar to FIG. **9**;

FIG. **11** is a side view of a yet further embodiment similar to FIG. **10**;

FIG. **12** is a section of an alternative arrangement of blank incorporating a supplementary component;

FIG. **13** is a plan view of a blank used in the forming of an automobile component;

FIG. **14** is a section on the line **14**—**14** of FIG. **13**;

FIG. **15** is a section similar to FIG. **14** showing a subsequent step in the forming;

FIG. **16** is a sectional view of the finished component;

FIG. **17** is a flow chart showing the sequence of steps performed in FIGS. **13**–**16**;

FIG. **18** is an exploded view of components of a further embodiment of blank;

FIG. **19** is a side view of the assembled blank of FIG. **18**;

FIG. **20** is a plan view of FIG. **19**;

FIG. **21** is a section of a further embodiment of the blank shown in FIG. **19**; and

FIG. **22** is a series of schematic representations of blanks formed using the embodiments of FIGS. **18**–**21**;

FIGS. **23**–**25** are a series of schematic representations of a further embodiment of a blank.

DESCRIPTION OF PREFERRED EMBODIMENT

Referring therefore to FIG. **1**, a pair of constituent parts **10, 20** which may have differing characteristics—in this case differing thicknesses—are each planar and formed from weldable sheet metal. As such, each has a pair of oppositely directed major surfaces **12, 14** and **22, 24** interconnected at the periphery by edges **16, 26** respectively.

The constituent parts **10, 20** are positioned in juxtaposition with one major surface **14** of the constituent part **10** overlying and in abutment with one of the major surfaces **22** of the constituent part **20**. The constituent part **10**, which is of smaller area than that of the constituent part **20**, is positioned within the periphery of part **20** such that after forming, an increased thickness of material will be available in the desired region of the finished component.

The constituent parts **10, 20** are secured in abutting relationship by clamps **32** of suitable form including magnetic clamps if the components themselves are magnetic. A laser **34** directs a beam **36** onto the exposed major surface **12** of the constituent part **10** and produces local melting of the constituent part **10** and the major surface **22**. The beam **36** is controlled so that partial penetration of the component **20** is obtained but the liquid region **38** does not extend to the lower surface **24**. The irradiated area may be shielded with an inert gas in a conventional manner as appropriate.

The beam **36** is caused to translate relative to the constituent parts **10, 12** along a predetermined path so that as the beam **36** moves, the constituent part **10** and part of the constituent part **20** melt locally in the region indicated by numeral **38**. Continued movement of the beam **36** allows the region **38** of the constituent parts **10, 20** to solidify after passage of the beam and be joined to one another as indicated by weld **40**.

As indicated in FIG. **3**, the beam **36** is repositioned laterally to provide welds at spaced locations and thereby secure the one constituent part **10** to the other constituent part **20**. Alternatively, multiple beams may be used to produce welds simultaneously.

After welding, the constituent parts **10, 20** provide a unitary tailored blank **42** which may then be subsequently formed into a component of the required shape as shown schematically in FIG. **4**. A pair of complementary dies **44, 46** engage opposite faces **12, 24** of the blank **42** to form it into a shape defined by the dies. The components **10, 20** are each formed resulting in a finished component of the desired complex shape.

By controlling the beam **36** such that melting only proceeds part way through the constituent part **20**, the major surface **24** is not adversely affected by the welding process and therefore presents a continuous smooth surface that may not require additional processing prior to finishing. At the same time, the blank provides varying material characteristics in the finished component. It will be appreciated that full penetration of the constituent part **20** may be permitted where final surface finish is not significant.

In tests conducted with the composite blank **42** shown in FIG. **3**, the following parameters were utilized:

relative speed between laser beam and the constituent part:	6.2 metres per minute
laser beam power:	6 kilowatts utilizing a CO_2 continuous laser;
laser beam mode:	TEM_{01}

-continued

laser beam diameter:	0.028 inches
shield gas:	helium above, argon below;
thickness of constituent part 20:	t^1 = 0.034 inches;
thickness of constituent part 10:	t^2 = 0.074 inches;
constituent part material:	galvaneal (hot rolled galvanized mild steel)

Naturally the constituent parts may be similar to one another having the same thickness and composition or may be selected with different characteristics, such as thickness, composition, coating or the like. By selecting the constituent part **10** of the appropriate characteristics, the unitary blank **42** is formed with a uniform surface but with local reinforcements to provide varying characteristics in the formed component. In one particularly beneficial embodiment, the constituent part **20** is zinc coated and the constituent part **10** is cold rolled steel. The surface **24** of the part **20** is thus not affected by welding to provide a continuous zinc coated surface that may be used as an exterior paint surface and/or for corrosion resistance.

Alternative arrangements of constituent parts and welding may be utilized to produce the required tailored blank. For example, as shown in FIG. **5**, the constituent part **10*a*** is secured to the constituent part **12*a*** through intersecting lines of welds **40*a*** indicated so that the constituent part **10*a*** is secured about its entire periphery to the constituent part **12**.

As shown in FIG. **6**, the constituent part **10*b*** need not be rectangular or even of regular shape, and the laser beam **36*b*** may be moved along a path conforming to the periphery of the constituent part **10*b*** to secure it to a differently-shaped constituent part **20*b***.

The above embodiments contemplate the welding of the constituent part at a location spaced from the periphery of the constituent part **10*a***. However, as indicated at FIG. **7**, the constituent part **10*c*** may be welded to the constituent part **12*c*** by following the edge of the constituent part and providing a lap weld **40*c*** along the periphery of the constituent part **10*c***. Again, where the major surface **24*c*** is to be used as a finished surface, the beam **36*c*** is controlled to limit penetration through the constituent part **20*c***.

The above embodiments show the formation of tailored blanks from generally planar constituent parts. However, as indicated in FIGS. **8–11**, tubular constituent parts **10*d*, 20*d*** may be utilized to provide local reinforcement in the walls of a tubular blank. As seen in FIG. **8**, the constituent part **10*d*** is tubular and located within tubular component **20*d***. Laser beam **36*d*** impinges on the radically outwardly-directed major surface **12*d*** and penetrates to the abutting major surfaces **14*d*, 22*d***, to weld the two surfaces together. The tubular constituent part **20 *d*** may be rotated about its longitudinal axis relative to the beam **36*d*** to produce a circumferential weld.

The constituent parts **10*d*, 20*d*** may of course be connected at longitudinally spaced locations to connect the constituent parts as required for subsequent forming.

This arrangement is particularly useful where the tubular blank **42*d*** is to be used in a hydroforming operation where high pressure fluid is used to expand a tubular blank **42*d*** into a die cavity. An example is shown in FIG. **9** where a radial expansion of the tubular blank **42*d*** produces a bulbous frame component with varying wall thickness. The local reinforcement provided by the part **20*d*** permits varying characteristics to be obtained along the length of the finished component.

As shown in FIG. **10**, the constituent part **20***e* may be provided externally of the tube **10***e* and at a number of longitudinally spaced locations. This facilitates placement of the parts **20***e* and permits tailoring of the tubular blank **42***e*. When used in vehicle frames, the variation of wall thickness provided by constituent parts **10***e*, **20***e* permits a progressive crush resistance to be obtained for the finished component. Similarly, as illustrated in FIG. **11**, multiple constituent parts may be stacked on top of one another to provide further variation in wall thickness. Of course, a similar stacking may be accomplished with planar components illustrated in FIGS. **1–7**.

The lamination of the tailored blank **42** also enables supplementary materials to be incorporated into the blank **42**. As shown in FIG. **12**, the sound transmission characteristics may be modified by incorporating a non-metal layer **48**, such as plastic or paper, between the constituent parts **10***g*, **20***g*. Typically, the intermediate layer **48** may be 0.004 inches thick and lies within the smaller constituent part **10***g* to separate the major surfaces **14***g*, **22***g* and provide a peripheral margin **50** in which contact between the surfaces **14***g*, **22***g* is not inhibited. The constituent parts may be seam welded around the peripheral margin **50** to inhibit moisture ingress or intermittently welded to retain the layer **48**. The resultant tailored blank **42***g* may then be formed to the required shape in a press with the intermediate layer **48** retained in situ during forming.

A further example of a component formed from a tailored blank is shown in FIGS. **13–16** where the formation of a shock tower for use in a vehicle body is shown using the process steps shown in FIG. **17**. A shock tower is used to support suspension components in a vehicle and as such is subjected to severe local shear loadings. However, the shock tower is usually elongated to accommodate the vertical displacement of suspension components and therefore has a significant wall area.

A blank **42***h* is formed from a constituent part **20***h* and a pair of first constituent parts **10***h*. The second constituent part **20***h* is formed from a planar sheet of cold rolled steel with a pair of D-shaped cutouts **52** located in local depressions **53**. The cutouts **52** and depressions **53** are provided in a preforming step by stamping a sheet of material in a conventional manner.

The first constituent parts **10***h* are cut from sheet stock which is thicker and of higher strength to serve as a mounting point and located over the cutouts **52**. The parts **10***h* overlap the edges of the cutouts **52** within the depression to provide a peripheral margin **54** of juxtaposed parts. The depth of the depressions corresponds to the thickness of the parts **10***h* so that the major surfaces **24***h* and **14***h* are coplanar. A flat surface is thus provided to facilitate subsequent forming operations.

The constituent parts **10***h*, **20***h* are then laser welded to one another in the margin **54** with a continuous weld **40***h* as indicated above.

The resultant blank **42***h* contains two individual blanks for forming the shock towers and so is separated along a line of symmetry **56** into individual blanks. Each individual blank is then formed in a press into a shock tower as shown in FIG. **16** with walls of relatively thin material but with mounting plates provided with a double thickness by the constituent parts **10***h*.

The techniques described above may also be utilized to provide a blank incorporating non-weldable components, or components that are not compatible for welding to one another. For example, mild steel and aluminum are each weldable but when welded to one another brittle, intermetallic compounds are formed.

One such arrangement is shown in FIGS. **18–20** in which a pair of constituent parts **10***j*, **20***j* are interconnected by welds **40***j* and are mechanically connected to an additional component **60**. The component **60** is a plastics material and has a series of rectangular depressions **62** along marginal edges **64**. An undercut **66** is formed on the edge of constituent part **10***j* with an undersurface **68** spaced from the major surface **24***j* by the thickness of the additional component **60**. Projections **70** depend from the undersurface **68** and are complementary to the depressions **62** so as to be a snug fit within them.

The constituent parts **10***j*, **20***j* are positioned in juxtaposition with the component **60** located between. The projections **70** engage the depressions **62** so that the component **60** is mechanically locked to the part **10***j*. The parts **10***j*, **20***j* are then welded at **40***j* to connect them and secure the component **60**. The resultant blank may then be formed with the mechanical connection retaining the integrity of the parts **10***j* and component **60**. It will be appreciated that the component **60** may be a plastics composite, glass or other material not normally weldable or could be a dissimilar metal material such as aluminum.

In another embodiment, as shown in FIGS. **23–25**, a blank assembly **101** comprises a first constituent part **110** with an aperture **112**. Aperture **112** is shown as rectangular. However, it is readily understood that aperture **112** can be any shape. The aperture **118** is formed in the constituent part **110** by any known method, for example, cutting or punching.

A second constituent part **114** is provided with an embossment **116** to fit the aperture and a surrounding flange **115**. The embossment **116** may be formed by any known method.

Embossment **116** includes a step **118** that preferably has a height equal to the thickness of the first constituent part **110**. The embossment **116** should be the same shape as and slightly smaller than the aperture **112** to provide a complementary fit therein.

Embossment **116** is nested in aperture **112** such that constituent part **110** is juxtaposed in a face to face relation with constituent part **114**. It is desirable for surface **120**, where it is formed into embossment **116**, to be flush with surface **122** of the first constituent part **110**. This arrangement of providing a flat surface allows for improved material flow during subsequent forming process.

The size and location of aperture **112** and embossment **116** is determined by where extra strength is required for the tailored blank. Preferably aperture **112** and embossment **116** are spaced inwardly from the outer edge of the constituent part **110**, **116** respectively.

A laser welder is directed along a path outside of the perimeter of the embossment **116** and aperture **112** thus joining the two constituent parts **110**, **116** together. The second constituent part **116** must be of sufficient size to allow for a weld to join the blanks together. The weld **124** is typically a lap weld and the weld location does not need to be accurate. It is also possible to place a fillet weld between the edge of constituent part **110** and the embossment **116**; however, this requires a higher precision operation. In another embodiment, the constituent parts **110** and **116** are secured via a mechanical connection.

As a further alternative to the rectangular depressions **62**, part-spherical recesses may be used as shown in FIG. **21**. In this embodiment, recesses or "dimples" **72** are formed in each of the parts **10***k*, **20***k* and component **60***k* by a part-spherical punch and the parts **10***k*, **20***k* welded to one another to form an integral blank **42***k*.

The mechanical interconnection of the component **60** and parts **10**, **20** may be utilized in a number of ways as shown in FIG. **22**. The component **60** may be used to cover an aperture in the part **20** as shown in FIG. **22***a*, or may form a lining over a portion of the part **20** as shown in FIG. **22***b*.

The component **60** may be circular as illustrated in FIG. **22***c* or may be formed with a peripheral rabett so that a flush surface is provided as shown in FIG. **22***d*.

In some circumstances, a positive mechanical connection is not necessary in which case a frictional location is obtained by deflection of one or both constituent parts as shown in FIGS. **22***e*–**22***h*. In such arrangements, the component **60** is mechanically trapped by the constituent parts to permit subsequent forming operations.

It will be seen that the preparation of a tailored blank with constituent parts juxtaposed permits the blank to be formed with different material characteristics without the need for precision edge preparation of the parts.

Other typical applications in which the above embodiments find utility are the provision of a strengthening section in a door skin of a vehicle to receive a door lock assembly or mounting pads for attachment of seat belts on a floor pan of a vehicle.

Although laser welding is preferred, alternative welding techniques may be used such as MASH welding that permits the blank to be assembled and subsequently formed. The welding pattern will be selected to meet the structural requirements of the forming process, including the drawing properties of the blank and the components' subsequent use.

By securing the constituent parts into a blank prior to forming, the need for accurately fitting the parts for seam welding into a unitary blank is mitigated. Moreover, because the required material characteristics can be obtained from the blank, the need to weld additional components after the forming process is avoided. This is particularly significant as the accurate fitting of complex shapes after forming is difficult and time-consuming. A uniform closed surface may also be obtained without relying upon the integrity of the weld.

In each of the above embodiments, a continuous weld has been illustrated between the constituent parts. Where structural requirements permit, it is of course possible to provide localized welding at discrete locations over the constituent parts so that the constituent parts are held together during forming but a continuous weld is not necessary.

The embodiments of the invention in which an exclusive property or priviledge is claimed are defined as follows:

1. A method of forming a component from a tailored blank having two constituent parts, comprising the steps of providing a first constituent part having an aperture; providing a second constituent part of substantially uniform cross section having an embossment to fit the aperture and a surrounding flange to extend beyond the periphery of said aperture and overlap the first constituent part, the embossment being offset from the flange by the thickness of the first constituent part; positioning said first and second constituent parts to face to face relation with said second constituent part nesting said embossment within said aperture; securing the first and second constituent parts to one another to form a substantially planar tailored blank by laser welding said flange to said first constituent part by continuous welding between the flange and first constituent part, wherein said step of nesting said embossment in said aperture results in a flush surface between said first constituent part and said embossment; and deforming said blank to provide said component.

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